STUDIES ON POWDERY MILDEWS OF COMPOSITAE IN SOME DISTRICTS OF UTTAR PRADESH

ABSTRACT

THESIS

SUBMITTED FOR THE DEGREE OF

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IN

BOTANY

BY

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DEPARTMENT OF BOTANY
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ABSTRACT

The major objective of the study was to establish the identity of powdery mildew species infecting composites in Uttar Pradesh (India). In order to achieve this objective, a study area consisting of ten districts was selected. Practically it could not be possible to encompass all the districts of the state and at the same time all the areas in the included districts. Surveys were conducted in different localities with extensive composite cultivation in the districts of Agra, Aligarh, Allahabad, Bareilly, Budaun, Bulandshahr, Etah, Etawah, Kanpur and Mathura in Uttar Pradesh. Acroclinium spp., C. officinalis, C. coronarium, Cineraria spp., Coreopsis spp., C. sulphureus, D. variabilis, D. sinuata, E. alba, H. annuus, X. strumarium and Z. elegans were found infected in various districts included in the study area during surveys. This study for the first time in India, consist such as large area, to establish the identity of powdery mildew species infecting composites. In addition to the identity of the species, consistency in anamorph characters in which the powdery mildew species were found, was examined in order to use them for identification of the involved species.

Identity of the causal organisms

Identification of powdery mildew species infecting various composites in different localities of the districts was established by using anamorph characters of the species.

Mode of parasitism in relation to ectophytic and endophytic nature of the mycelium, morphology of conidiophores in relation to branching, arrangement of conidia on conidiophres, shape of conidia, presence or absence of fibrosin bodies in conidia, mean number of fibrosin bodies per conidium, morphology of germ tubes and development of appressoria and point of origin of germ tubes on conidia were studied and dimensions (length and breadth) of conidia were measured and length/breadth (L/B) ratio of conidia was determined.

Erysiphe cichoracearum and Sphaerotheca fuliginea were identified as the species causing the disease on composites in all the districts. E. cichoracearum was found infecting Acroclinium spp., Coreopsis spp., C. sulphureus, D. variabilis, E. alba, X. strumarium and Z. elegans from all the surveyed districts. Whereas, S. fuliginea was found infecting Cineraria spp, C. officinalis and H. annuus. Beside these plants, C. coronarium and D. sinuata were also found with infection in few districts. C. coronarium was infected with E. cichoracearum in the districts of Agra, Aligarh, Etawah, Kanpur and Mathura. Similarly, D. sinuata was found

infected with S. fuliginea from Aligarh and Budaun districts respectively. The study establishes the identity of Compositae powdery mildew as E. cichoracearum and S. fuliginea, though E. cichoracearum was predominant and mainly responsible for the disease on the members of this family.

Consistency in anamorph characters

A number of anamorph characters particularly presence or absence of well developed discrete fibrosin bodies, mean number of fibrosin bodies per conidium, conidial dimensions (length and breadth) and length/breadth (L/B) ratio of conidia, forking of germ tubes and appressorial development and point of emergence of germ tubes from the conidium was examined for their consistency. The characters showed a great degree of consistency and were found valuable for differentiating E. cichoracearum from S. fuliginea.

The conidia of powdery mildew indentified as S. fuliginea possessed well developed fibrosin bodies. Though in some samples all conidia did not show fibrosin bodies, a fairly high percentage contained them. Mean number of fibrosin bodies per conidium in various samples ranged between 7.38 to 9.01. Conidia of S. fuliginea produced simple and forked germ tubes and did not develop appressoria. The per cent forking of germ tubes was between 47.96 to 56.36. The germ tubes emerged from the side wall of the conidium.

Conidia of the powdery mildew identified as E. cichoracearum did not contain fibrosin bodies. On germination they invariably produced simple and straight germ tubes which later developed club-shaped appressoria. The germ tubes emerged apically/basally. The conidia of S. fuliginea were ellipsoidal whereas of E. cichoracearum were barrel shaped tending to become cylindrical. L/B ratio of conidia for the species was more or less constant being more than 2 (mostly 2.10) for E. cichoracearum and less than 2 (mostly 1.80) for S. fuliginea.

Host range studies

In the host range studies it was observed that Cineraria spp. and Z. elegans were susceptible to D. variabilis isolate of E. cichoracearum, However, D. variabilis and H. annuus were susceptible to Z. elegans isolate of E. cichoracearum both in the glasshouse as well as in the field conditions. The isolates of E. cichoracearum from A. esculentus (Malvaceae), B. hispida and C. cordifolia (Cucurbitaceae) fail to parasitize the Compositae members. It was assumed that the isolates of E. cichoracearum from composites appear to be different from those of non-composites.

Isolates of E. cichoracearum from composites gave different response among various Compositae members, it shows that there may exists various strains of E. cichoracearum having specificity among the composites.

Varietal resistance

Out of the ninty nine cultivars of cultivated composites tested for their resistance, it was found that reaction against E. cichoracearum isolates from C. sulphureus, C. coronarium, D. variabilis and Z. elegans showed resistance to few cultivars. It was observed that the cultivars of C. officinalis (Double mixed); C. coronarium (Maxima may queen, Annual mixed, Selection mixed and Coronarium mixed); Cineraria spp. (Maxima mixed colours); C. sulphureus (Sensation mixed, Choice mixed, Goldcrest, Sunset, Bright lights, Candy stripe, Early flowering mixed, Double crested mixed); D. variabilis (Dwarf double redskin, Coltless hybrid mixed, Dwarf border mixed, Unwins bedding, Decorative mixed, Exhibition mixed); H. annuus (Miniature mixed, Japanese miniature mixed, Brown fancy mixed); L. sativa (Local) and Z. elegans (Violet queen, Giants of California mixed, Linearis white, Golden dawn, Purple prince, Dahlia flowered mixed and California giant mixed) were highly susceptible to resistant against these isolates in glasshouse and field conditions.

The host response in general, in glasshouse and field was found to be the same. In few cases it was noticed that the same cultivar remains susceptible under glasshouse but becomes resistant in the field or vice versa. It can be concluded that the glasshouse conditions were a bit controlled and conducive for the powdery mildew development.

Chemical control

The comparative efficacy of three commercial fungicides viz. Karathane EC (48 per cent 1-methyl-heptyl) phenylcrotonate, Bavistin (50 per cent 2-methoxy-carbamoyl) benzimidazole) and Morestan (25 per cent 6-methyl-quinoxaline-2,3. dithiocarbonate) was evaluated against powdery mildew (E. cichoracearum) on Dahlia variabilis cv.Decorative mixed. Out of the different concentrations of the fungicides applied, higher concentration (0.02 per cent) of the fungicidal spray was found to be most effective in controlling the disease. The best performance was observed with the application of Karathane EC followed by Bavistin and Morestan.

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CERTIFICATE

This is to certify that **Mr. Saiyed Iqbal Husain** has worked in this department as a Research Scholar under my supervision and guidance. His work on the **"Studies on powdery mildews of Compositae in some districts of Uttar Pradesh"** is upto-date and original. He is allowed to submit his thesis for the consideration of the award of the degree of Doctor of Philosophy in Botany.

Mohd. Akram

(DR. MOHD. AKRAM)

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(SAIYED IQBAL HUSAIN)

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INTRODUCTION

Powdery Mildews

The powdery mildew was first recognized as white powdery appearance on the leaf of Humulus, Acer, Lamia, Galeopsis and Lithospermum by Linnaeus (1753) and he gave the name Mucor erysiphe. The Erysiphaceae was perhaps first recognized as a taxonomic group by Leveille (1851). The taxonomy about the members of this family given by Salmon (1900), Homma (1937) and Blumer (1967) was stablized since last 67 years. During this period various workers viz. Sawada (1914), Brundza (1933), Yarwood (1957) and Hirata (1966) also studied the taxonomy of these pathogens. The number of genera of Erysiphaceae range upto at least eighteen (Hirata, 1966). Blumer (1967) divided the entire Erysiphaceae family into eight genera and Amano (1986) classified it under twenty genera.

Erysiphaceae are parasitic on 7187 host species of 1289 genera belonging to 149 families, and 44 orders of Angiosperms (Hirata, 1966). About 90 per cent of these are Dicotyledons, and only one species of powdery mildew i.e. Erysiphe graminis is known to attack Monocotyledons. This wide host range for a specific group of foliage pathogens is probably exceeded only by the rusts (Uredinales). Hosts of powdery mildew include some 13-38 per cent of the total Angiosperms in a geographic region (Hirata, 1966).

The powdery appearance of this disease is caused by the mycelium and maturing conidia which are formed on erect conidiophores borne singly at right angles to the leaf surface. The conidiophores are a chain of cells which are shorter but of greater diameter than hyphal cells. Conidia are typically ellipsoidal, with thin walls and numerous conspicuous vacuoles of water. Powdery mildews occurs primarily on the leaves, buds, flowers and fruits. Other characteristics of powdery mildews are the occurrence of haustoria in the host's epidermal cells; their luxuriant development in rain-free seasons; the high water content of large, turgid. passively liberated, airborne conidia. Generally powdery mildews are favoured by succulent host tissues and by cool, shaded environments. Fibrosin bodies - refractive, straight, or curved rod like structures are present in the conidia of Sphaerotheca and Podosphaera.

The areas of greatest abundance and of damage due to Erysiphaceae appear from the literature is to be California and Israel; both are characterized by rain-free summers with intensive agriculture. Treatments which favour are, succulent growth and large leaves, tillage of the soil (When weeds are abundant), shading, induction of water sprouts of woody plants and fertilization appears to favour powdery mildew. Liming of soil (Hirata, 1968; Vlamis and Yarwood, 1962) and low soil moisture (Yarwood, 1957) also favour the infection.

Erysiphaceae occur predominantly on cultivated plants and are more destructive on cultivated than on wild plants (Blumer, 1933).

Extensively studied and economically most important powdery mildews are Erysiphe cichoracearum, E. graminis, Sphaerotheca fuliginea and Uncinula necator.

Family : Compositae

The family Compositae is one of the largest family of flowering plants, comprising about 900 genera and over 13,000 species. It is widely distributed and cosmopolitan in habit. Members of this family constitute about 10 per cent of the entire flowering plants. In India, it is represented by about 138 genera and 708 species occurring chiefly in the Himalayas and on the mountains of Southern and Western India ascending upto about 6,000 metres. About 52 per cent of the species are endemic in nature. The family plays an important role in the vegetation of an area ranging from the arctic region right upto the sub-tropics; in the tropics themselves, it avoides the rain forests but occurs in arid zones and mountains also.

Economically this family is of great importance, large number of plants are extremely ornamental viz. Helianthus annuus, Tagetes erecta, Chrysanthemum coronarium, Dahlia variabilis and Zinnia elegans. Some members are important as a source of food to man, such as lettuce (Lactuca sativa), globe artichoke (Cynara scolymus), endive (Cichorium sp.) salisfy (Tragopogon porrifolius) and cichory (Cichorium intybus). Many are noxious weeds and others are medicinally important e.g. (Artemisia absinthium (worm wood) and the roots of Doronicum roylei are used as aromatic

tonics. Artemisia cina, A. maritima and A. nilagarica yield Santonine, which is used for expelling worms. Matricaria chamomilla (Midteranean) is the source of chamomille a medicine, other medicinal plants are Anthemis nobilis, Calendula officinalis, Filago germanica, Tanacetum vulgare, Vernonia anthelmintica, Solidago sp., Blumea lacera, Eclipta alba, Lactuca sativa, Taraxacum officinale and Sonchus oleraceus. Some most economically important plants are as follows;

Calendula officinalis Linn.

C. officinalis and C. arvensis grow wild as well as cultivated for their beautiful yellow heads. Its flowers and plants are used to treat wounds and injuries. The flowers of C. arvensis are reputed as stimulant and antiseptic.

Cosmos sulphureus Cav.

C. sulphureus or the yellow cosmos is a herb, native to Tropical America and is now cultivated in Indian gardens. The flowers yield an orange red dye. C. bipinnatus is another commonly cultivated species which has many ornamental varieties.

Dahlia variabilis Desf.

It has immeasureable varieties that are grown as ornamentals throughout the world. All these varieties go back to D. pinnata (D. variabilis) and D. coccinea that are indigenous to Mexico. From the tubers of it a polysaccharide, inulin is obtained which is used

for commercial preparation of fructose.

Eclipta alba Linn.

It grows wild throughout India. It prefers moist places. The plant is used for the cure of spleen and liver enlargements, its roots are purgative.

Helianthus annuus Linn.

The genus includes about 100 species. H. annuus is commonly grown as garden ornamental. Its seeds are a source of an oil, which is used in food preparations. It is also used in making soap, varnish and paint. H. tuberosus (Jerusalem artichoke) is a perennial herb cultivated all over India for its edible stem tubers, which are also used in the manufacture of Industrial alcohol. The plants are also grown as a forage crop and weed eradicator.

Lactuca sativa Linn.

Lettuce, a native of Southern Europe and Western Asia, is descended from the wild lettuce (L. scarriola) a common weed of roadsides and wastelands. Seven species grow commonly in India. L. sativa is cultivated throughout India for its edible leaves that are used as salad. The plant has a cooling, sedative, diuretic, diaphoretic and hypnotic properties. Earlier it was cultivated only in home gardens, now it is an important crop and thrives best in sandy or loamy soil and requires cool weather. The other common Indian species are L. dissecta, L. scarriola and L. polycephala.

Xanthium strumarium Linn.

It includes 30 cosmopolitan species and is distributed throughout India. X. strumarium is diaphoretic, sedative and is considered useful in long standing cases of malaria. The root is bitter tonic, useful in strumous diseases and cancer. The fruit is given in small pox.

Zinnia elegans Jacq.

It includes many species that are grown as garden ornamentals. It has many varieties (e.g. Z. angustifolia) that are grown as ornamentals.

In this programme of research, considering various aspects related to the powdery mildew of the Compositae, important for tackling the disease, the following aspects have been studied.

1. To survey the incidence and intensity of powdery mildew on different members of the family Compositae in some districts of Uttar Pradesh.
2. Identification of the causal organisms in order to establish the pathogens of powdery mildews of Compositae in some districts of Uttar Pradesh.
3. Consistency in anamorph (conidial) characters for their use in the identity of Erysiphe cichoracearum and Sphaerotheca fuliginea.
4. Host range studies of both the pathogens.
5. To study the resistance among indegenous Compositae cultivars (varieties) against Erysiphe cichoracearum pathogen.
6. Chemical control of powdery mildew.

LITERATURE REVIEW

The family Compositae constitute important ornamental plants which are found in almost all the parts of the world and are grown for their beautiful flowers and due to their immense economic importance. The members of this family are not free from the diseases, they are attacked by Virus, Bacteria, Fungi and Nematodes. Among fungal diseases, the powdery mildew is most common on both cultivated and wild composites (Salmon, 1900; Homma, 1937; Hirata, 1966; Blumer 1967; Kenneth and Palti, 1984). The distribution and severity of powdery mildews depends on a dynamic state of conditions and involve a balance of favourable and unfavourable environmental factors that directly affect germination, infection, growth, sporulation and dissemination, as well as the factors that directly affect the development of the pathogen through their influence on host physiology (Schnathorst, 1965). Powdery mildews are generally favoured by relatively moderate to high temperature, high soil moisture, reduced air circulation and light intensity, fertile soil, succulent plant growth and continuous cropping (Yarwood, 1957).

Occurrence of powdery mildew on Compositae in different Geographic regions of the world

Powdery mildew on Compositae is noted to occur in all the geographical regions of the world (Hirata, 1968; Amano, 1986). Records of this disease on different members of Compositae in

various countries is given in Table-1. While Tables 2-6 clearly indicates the occurrence of different species of powdery mildew on Compositae. Reports of teleomorphs (perithecia) of Erysiphe cichoracearum, Sphaerotheca fuliginea and Leveillula taurica on Compositae members in different parts of the world is presented in Table - 7. Similarly, records of occurrence of powdery mildew on Compositae in different states of India and the species reported is given in Table - 8.

Causal Organism

Majority of the powdery mildew including species attacking Compositae, seldom produce perithecia. The perithecia, are of limited value in taxonomy of powdery mildews because most collections do not contain them, only 13 per cent of 515 collections listed by Gardner and Yarwood (1974) contained perithecia. Tropical and sub-tropical regions contain many powdery mildews but perithecia are uncommon (Hansford, 1961; Bessey, 1961; Clare, 1964; Blumer, 1967). Laibach (1930) indicated that the old leaves, low state of host nutrition, dry atmosphere and low temperature favour perithecial formation. Continuous culture in the glasshouse may lead to the loss of perithecial formation (Mamluk and Weltzein, 1973).

Teleomorphs of Erysiphe cichoracearum DC. ex. Merat. and Sphaerotheca fuliginea (Schlecht.) Poll. are claimed to have been recorded on different members of Compositae (Schnathorst, 1959; Lebeda and Buczkowski, 1986; Tanaka et al. 1986; Rostam, 1983).

Table 1

Occurrence of powdery mildew of Compositae in different countries of the world

Asia	Africa	Europe	N. America	S. America	Pacific
Afghanistan, Borneo, Brunei, China, Cambodia, Hongkong, India, Iran, Iraq, Israel, Java, Jordan, Korea, Lebanon, Mongolia, Nepal, Pakistan, Sri Lanka, S. Arabia, Syria, Singapore, Thailand, Turkey, U.S.S.R.-Asian region, Yemen.	Algeria, Canary Is., Egypt, Ethiopia, Guinea, Kenya, Libya, Mauritius, Madeira Is., Malawi, Malagasy Rep., Morocco, Mozambique, Niger, Rhodesia, S. Africa, Sudan, Sicily, Sierra Leone Tanzania, Tunisia, Uganda, Zambia, Zaire.	Austria, Andoora, Belgium, Balearic Is., Britain, Bulgaria, Corsica, Crete, Cyprus, Czechoslovakia, Denmark, Faeroes, Finland, France, Germany, Greece, Hungary, Italy, Ireland, Iceland, Malta, Norway, Netherland, Poland, Portugal, Romania, Shetland Is., Spain, Spanish Sahara, Svalbard, Sweden, Switzerland, U.S.S.R.-European region, Yugoslavia.	Alaska, Bermuda, Barbados Is., Canada, Cuba, Costa Rica, Dominican Rep. El Salvador, Guatemala, Greenland, Haiti, Honduras, Jamaica, Mexico, Panama, Puerto Rico, Tropical America, Trinidad and Tobago, U.S.A., W. Indies.	Argentina, Brazil, Bolivia, Chile, Columbia, Ecuador, Guyana, Paraguay, Peru, Uruguay, Venezuela.	Australia, Fiji, Formosa (Taiwan), Hawaiian Is., Japan, New Caledonia, New Guinea, New Zealand, Tasmania, Western Samoa.

Adopted from Amano (1986).

Table 2

Occurrence of Erysiphe cichoracearum as the causal organism of powdery mildew of Compositae in different countries of the world

Asia	Africa	Europe	N. America	S. America	Pacific
Afghanistan, China, India, Iran, Iraq, Israel, Jordan, Korea, Lebanon, Mongolia, Nepal, Pakistan, Sri Lanka, S. Arabia, Turkey, U.S.S.R.-Asian region, Yemen.	Algeria, Canary Is., Egypt, Ethiopia, Libya, Mauritius, Madeira Is., Morocco, Niger, Rhodesia, S. Africa, Tanzania, Tunisia.	Austria, Balearic Is., Belgium, Britain, Bulgaria, Corsica, Crete, Czechoslovakia, Denmark, Faeroes, Finland, France, Germany, Greece, Hungary, Italy, Iceland, Norway, Netherland, Poland, Portugal, Romania, Spain, Spanish, Sahara, Sweden, Switzerland, U.S.S.R.-European region, Yugoslavia.	Alaska, Bermuda, Canada, Cuba, El Salvador, Guatemala, Malawi, Mexico, Panama, Puerto Rico, U.S.A.	Argentina, Bolivia, Brazil, Chile, Ecuador, Peru, Venezuela.	Australia, Fiji, Formosa (Taiwan), Hawaiian Is., Japan, New Caledonia, New Zealand, Tasmania.

Adopted from Amano (1986).

Table 3

Occurrence of Sphaerotheca fuliginea as the causal organism of powdery mildew of Compositae in different countries of the world

Asia	Africa	Europe	N. America	S. America	Pacific
Afghanistan, China, India, Iran, Iraq, Israel, Korea, Lebanon, Pakistan, Turkey, U.S.S.R.- Asian region.	Canary Is.,Egypt, Morocco, Rhodesia, S. Africa, Sudan, Tanzania.	Austria, Andoora, Belgium, Britain, Bulgaria, Corsica, Crete, Czechoslovakia, Denmark, Faeroes, Finland, France, Germany, Greece, Hungary, Italy, Iceland, Malta, Norway, Netherland, Poland, Portugal, Romania, Spain, Sweden, Switzerland, Svalbard, U.S.S.R.- European region, Yugoslavia.	Alaska, Canada, Dominican Rep., Greenland, Mexico, Puerto Rico, U.S.A.	Chile, Paraguay.	Australia, Formosa (Taiwan), Japan, New Zealand, Tasmania.

Adopted from Amano (1986).

Table 4

Occurrence of Leveillula taurica as the causal organism of powdery mildew of Compositae in different countries of the world

Asia	Africa	Europe	N. America	S. America	Pacific
Afghanistan, China, India, Iran, Iraq, Israel, Jordan, Lebanon, Mongolia, Pakistan, Syria, S. Arabia, Turkey, U.S.S.R.-Asian region.	Algeria, Canary Is., Egypt, Ethiopia, Kenya, Mauritius, Malagasy Rep., Morocco, Mozambique, Sicily, Sudan, Tanzania, Tunisia.	Britain, Bulgaria, Corsica, Crete, Czechoslovakia, Cyprus, France, Germany, Greece, Hungary, Italy, Malta, Poland, Portugal, Romania, Spain, Switzerland, U.S.S.R.-European region, Yugoslavia.	U.S.A.	----	New Caledonia.

Adopted from Amano (1986).

Table 5

Occurrence of both E. cichoraccarum and S. fuliginea as the causal organism of powdery mildew of Compositae in different countries of the world

Asia	Africa	Europe	N. America	S. America	Pacific
Aghanistan, China, India, Iran, Iraq, Israel, Korea, Lebanon, Pakistan, Turkey, U.S.S.R.-Asian region.	Canary Is., Egypt, Morocco, Rhodesia, S. Africa, Tanzania.	Austria, Belgium, Britain, Bulgaria, Corsica, Crete, Czechoslovakia, Denmark, Faeroes, Finland, France, Germany, Greece, Hungary, Italy, Iceland, Norway, Netherland, Poland, Portugal, Romania, Spain, Sweden, Switzerland, U.S.S.R.-European region, Yugoslavia.	Alaska, Canada, Mexico, Puerto Rico, U.S.A.	Chile.	Australia, Formosa (Taiwan), Japan, New Zealand, Tasmania.

Adopted from Amano (1986).

Table 6

Reports of occurrence of powdery mildew of Compositae in different countries of the world

Country	Causal Organism	Basis of the Identification	Reference
Asia			
China	Erypsiphe cichoracearum	Anamorph	Yang (1988)
India	Sphaerotheca fuliginea	Both	Jhooty (1965)
India	Leveillula taurica	Both	Paul and Kapoor (1982)
India	E. cichoracearum	Anamorph	Perwez and Akram (1987)
Iran	L. taurica	Anamorph	Doustdar (1958)
Israel	L. taurica	Anamorph	Rayss (1940)
Israel	E. polygoni, S. fuliginea Oidiopsis taurica	Anamorph	Eshed (1975)
Israel	E. cichoracearum S. fuliginea	Anamorph	Kenneth and Palti (1984)
Lebanon	L. taurica	Both	Saad et al. (1972)
U.S.S.R.	L. taurica	Anamorph	Gaponenko (1976)
U.S.S.R.	E. cichoracearum	Anamorph	Drozdovskaya (1980)
U.S.S.R.	Oidium chrysanthemi	Anamorph	Grigalyunaite and Shpokauskene (1982)
U.S.S.R.	E. cichoracearum S. fuliginea	Anamorph	Puzanova (1992)

Contd.

Table 6 (Contd.)

Africa			
Egypt	Erypsiphe sp., Sphaerotheca sp., Leveillula sp.	Anamorph	El-Kazzaz et al. (1992)
Libya	E. cichoracearum	Both	Khan and Mussa (1979)
Libya	E. cichoracearum	Both	Khan (1980)
Libya	S. fuliginea	Anamorph	Khan (1982)
Libya	E. cichoracearum	Anamorph	Khan and Faraj (1982)
Morocco	L. taurica	Anamorph	Besri and Hormattallah (1985)
S. Africa	E. cichoracearum, S. xanthii	Teleomorph	Gorter and Eicker (1983)
Tunisia	L. taurica	Anamorph	Laudanski et al. (1957)
Europe			
Austria	O. chrysanthemi	Anamorph	Plenk et al. (1992)
Britain	E. cichoracearum	Anamorph	Crute and Burns (1983)
Britain	E. fischeri	Anamorph	Bevan (1985)
Britain	E. cichoracearum	Anamorph	Clay et al. (1992)
Bulgaria	E. cichoracearum f. sp. helianthi	Anamorph	Shopov (1976)
Bulgaria	E. cichoracearum f. sp. helianthi	Anamorph	Mitov and Popov (1980)
Czechoslovakia	E. cichoracearum	Anamorph	Lebeda (1986)
Czechoslovakia	E. cichoracearum	Teleomorph	Lebeda and Buczkowski (1986)
France	L. taurica	Both	Traimer (1963)
France	E. cichoracearum	Both	Hasan (1974)
France	L. taurica	Both	Rostam (1983)

Contd.

Table 6 (Contd.)

France	Leveillula sp.	Anamorph	Durrieu and Rostam (1984)
Germany	E. cichoracearum	Anamorph	Braun (1980)
Germany	E. cichoracearum	Anamorph	Klemm (1986)
Italy	L. taurica	Both	Ciccarone (1955)
Italy	E. cichoracearum	Anamorph	Lorenzini and Triolo (1981)
Italy	E. cichoracearum	Anamorph	Ialongo (1981)
Italy	E. cichoracearum	Anamorph	Ialongo (1987)
Portugal	S. fuliginea	Anamorph	De'Verennes and De'Sequeira (1964)
Romania	E. cichoracearum	Anamorph	Eliade (1975)
Romania	S. fuliginea	Anamorph	Capetti and Gabriela (1976)
Scotland	E. cichoracearum	Anamorph	McDonald (1939)
Switzerland	E. cichoracearum, E. mayorii	Anamorph	Blumer (1974)
N. America			
Canada	E. cichoracearum	Anamorph	Mckeen et al. (1966)
Canada	E. cichoracearum, S. fuliginea	Both	Parmelee (1977)
Canada	E. cichoracearum	Anamorph	Dhanvantari and Jarwis (1985)
Mexico	E. cichoracearum	Anamorph	Diaz Franco (1985)
U.S.A.	E. cichoracearum	Anamorph	Yarwood (1936)

Contd.

Table 6 (Contd.)

U.S.A.	*E. cichoracearum*	Anamorph	Yarwood (1936)
U.S.A.	*E. cichoracearum*	Both	Schnathorst *et al.* (1958)
U.S.A.	*E. cichoracearum*	Both	Schnathorst (1959)
U.S.A.	*E. cichoracearum*	Anamorph	Morrison (1960)
U.S.A.	*E. cichoracearum*	Anamorph	Pady *et al.* (1969)
U.S.A.	*Oidiopsis taurica*	Anamorph	Koike *et al.* (1988)
S. America			
Argentina	*S. fusca*	Both	Cabrera and Mazzanti (1992)
Brazil	*E. cichoracearum*	Both	Deslandes (1954)
Pacific			
Japan	*E. cichoracearum*, *S. fuliginea*	Anamorph	Yukihiko (1975)
Japan	*E. cichoracearum*	Anamorph	Yukihiko (1980)
Japan	*S. fuliginea*	Both	Tanaka *et al.* (1986)
New Zealand	*S. fuliginea*	Anamorph	Boesewinkel (1979a)
New Zealand	*E. cichoracearum*, *S. fuliginea*	Anamorph	Boesewinkel (1979)
Taiwan	*S. fuliginea*	Anamorph	Hou and Lee (1981)

Table 7

Records of teleomorphs of powdery mildew of Compositae in different countries of the world

Country	Host Plant	Reference
Erysiphe cichoracearum		
Brazil	Helianthus annuus, Lactuca scariola	Deslandes (1958)
Czechoslovakia	Lactuca spp.	Lebeda and Buczkowski (1968)
Libya	Amberboa lippii	Khan and Mussa (1979)
Libya	Hedypnois cretica	Khan (1980)
U.S.A.	L. sativa	Schnathorst et al. (1958)
U.S.A.	L. sativa	Schnathorst (1959)
U.S.A.	H. annuus	Morrison (1960)
Sphaerotheca fuliginea		
Argentina	Calendula officinalis	Cabrera and Mazzanti (1992)
India	Zinnia elegans	Jhooty (1965)
Japan	Carthamus tinctorius	Tanaka et al. (1986)
Japan	H. annuus	Homma (1937)

Contd.

Table 7 (Contd.)

Leveillula taurica		
France	Cynara cardunculus	Traimer (1963)
France	Chondrilla juncea	Rostam (1983)
India	Senecio chrysanthemoides	Paul and Kapoor (1982)
Israel	Carlina involucrata, Tolpis vigrata	Rayss (1947)
Italy	Cynara scolymus	Ciccarone (1955)
Lebanon	C. scolymus, C. tinctorius, Echinops viscosus, Gundelia tournefortii, L. scariola	Saad et al. (1972)
Tunisia	C. scolymus	Laudanski (1957a)

Table 8

Reports of occurrence of powdery mildew of Compositae in different states in India

State	Causal Organism	Basis of the Identification	Reference
Assam	*Oidium* sp.	Anamorph	Roy (1973)
Bihar	*Oidium* sp.	Anamorph	Dutta (1974)
Delhi	*Leveillula taurica*	Both	Paul and Kapoor (1982)
Himachal Pradesh	*Erysiphe artemisiae*	Anamorph	Paul and Munjal (1982)
	Oidium sp.		
Himachal Pradesh	*Sphaerotheca fuliginea*	Both	Srivastava and Rawat (1982)
Kashmir	*S. fuliginea*	Teleomorph	Malik *et al.* (1973)
Kashmir	*E. cichoracearum*	Both	Narain and Saksena (1974)
Kashmir	*L. taurica*	Both	Paul and Kapoor (1982)
Maharashtra	*E. cichoracearum*	Both	Saluja and Bhide (1962)
Maharashtra	*S. fuliginea*	Both	Patwardhan (1964)
Maharashtra	*S. fuliginea*	Anamorph	Raut and Kale (1978)
Maharashtra	*Oidium* sp.	Anamorph	Deshpande and Dake (1978)
Madhya Pradesh	*E. cichoracearum*	Anamorph	Saxena and Saksena (1981)
Rajasthan	*Oidium xanthami*	Anamorph	Bhatnagar and Kothari (1966)
Rajasthan	*S. fuliginea*	Both	Prasada *et al.* (1968)
Rajasthan	*L. taurica*	Anamorph	Desai *et al.* (1970)

Contd.

Table 8 (Contd.)

Rajasthan	*L. taurica*	Anamorph	Prasada *et al.* (1971)
Rajasthan	*L. taurica*	Anamorph	Mathur *et al.*(1971)
Rajasthan	*S. fuliginea*	Both	Mathur *et al.* (1971)
Uttar Pradesh	*S. fuliginea*	Anamorph	Akram *et al.*(1975)
Uttar Pradesh	*E. cichoracearum*	Anamroph	Khan *et al.* (1977)
Uttar Pradesh	*E. cichoracearum*	Anamorph	Kanaujia and Singh (1977)
Uttar Pradesh	*S. fuliginea*	Anamorph	Akram and Khan (1977)
Uttar Pradesh	*Oidium agerati*	Anamorph	Singh and Singh (1977)
Uttar Pradesh	*S. fuliginea*	Both	Srivastava and Rawat (1982)
Uttar Pradesh	*Erysiphe* sp.	Anamorph	Jain (1984)
Uttar Pradesh	*E. cichoracearum*	Anamorph	Perwez and Akram (1987)
Uttar Pradesh	*E. cichoracearum*	Anamorph	Husain *et al.* (1992)

Erysiphe cichoracearum and Sphaerotheca fuliginea

The best documented powdery mildew pathogen of the family Compositae is E. cichoracearum. This is recognized by its two spored asci and basally inserted appendages which are much longer than the diameter of the ascocarp. It resembles S. fuliginea in possessing conidia in long chains which has possibly led to confusion in some reports. Conidia of S. fuliginea produce forked germ tubes whereas, those of E. cichoracearum form straight germ tubes and well differentiated appressoria (Zaracovitis, 1965). The pathogen has world wide distribution; Blumer (1967) distinguished 13 formae speciales based on a single species or a single section of a genus. A biologic form on Safflower (Carthamus tinctorius) was named E. cichoracearum f. sp. carthami by Milovtzova (1937), while wild and cultivated lettuce appear to be attacked by separate strains (Schnathorst et al., 1958). Clare (1964) and Yarwood (1973) also attempted to provide a key to indentify a variety of genera and species by their anamorph characters. They did not include the appressoria, germ tubes and secondary mycelium, but they included the type of host plant in their key; according to them, the genus Erysiphe occurs on herbs and can thus be distinguished from the genus Microsphaera which occurs on trees. The presence of a particular species of powdery mildews on a host is often influenced by the time of year. For example, in New Zealand E. cichoracearum and E. polyphaga occur early in the growing season on Sunflower (Helianthus annuus) and disappear several weeks later, to be replaced on the same plants by S. fuliginea (Boesewinkel, 1980).

In addition to L. taurica (Rostam, 1983; Ciccarone, 1955) both S. fuliginea and E. cichoracearum have been reported from Europe (Reid, 1986; Crute and Burns, 1983; Braun, 1980; Hasan, 1974), where the later predominates. E. cichoracearum was recognized as powdery mildew of Compositae in Italy (Ialongo, 1980, 1981, 1987; Lorenzini and Triolo, 1981). On the basis of morphology of conidia and results of inoculation of various hosts, the pathogen of a new disease on H. tuberosus was identified as E. cichoracearum (Ialongo, 1981; Lorenzini and Triolo, 1981). On the other hand the fungus isolated from Sonchus oleraceous, growing wild in Rome, was pathogenic only to Sonchus spp. on inoculating a wide range of plants (Ialongo, 1980). Beside E. cichoracearum, S. fuliginea was also newly recorded on Gerbera jamesonii in Italy (Ialongo, 1987). In Romania Eliade (1975) reported E. cichoracearum on Achillea coaractata and Zinnia elegans. Host records for various species of medicinal plants at Domnesti, Romania was given by Capetti and Gabriela (1976), there are five species of Calendula and a single of Hieracium, and the powdery mildew species was reported as S. fuliginea. Powdery mildew of Sunflower and Jerusalem artichoke in Bulgaria was reported by Mitov and Popov (1980) and Shopov (1976), E. cichoracearum f. sp. helianthi occurs on Sunflower and frequently on Jerusalem artichoke (H. tuberosus); it also infects H. scaberimus. In inoculation tests conidia from Sunflower infect H. tuberosus and H. scaberimus, and those from H. tuberosus infect Sunflower.

The occurrence of powdery mildew of lettuce in U.S.A., on wild and cultivated lettuce, is well documented (Schnathorst et al., 1958). In Europe however, there is less information on its distribution and biology on Lactuca sp. (Blumer, 1967; Dixon, 1978; Crute and Burns, 1983; Lebeda, 1984, 1985a&b). According to Boesewinkel (1979, 1980) and Hammett (1977), there is considerable information available on the asexual (anamorph) stage of the fungus (E. cichoracearum DC. ex. Merat.), but not on the sexual (teleomorph) stage. In Czechoslovakia, Lebeda and Buczkowski (1986), reported teleomorph of E. cichoracearum on L. serriola, L. saligna and L. aculeata, and all these species are found to be wild in nature. While, Crute and Burns (1983) and Crute et al. (1987) reported E. cichoracearum as the pathogen on some pot grown cultivated lettuce plants (L. sativa cv. Great-Lakes) under glasshouse conditions in United Kingdom. Beside, Lactuca sp. they also found the anamorph stage of the fungus on Senecio vulgaris and Sonchus oleraceous, and the fungus reported was same with those found on Lactuca sativa. Klemm (1986) also reported E. cichoracearum on L. sativa from Germany, and this was reported to be the first report of yield losses on lettuce caused by powdery mildew. Resistance in Senecio vulgaris to E. fischeri was studied by Bevan (1985) in United Kingdom. Out break of powdery mildew disease on Cinerarias for the first time recorded in Scotland and it was studied by McDonald (1939).

In addition to E. cichoracearum, S. fuliginea was also reported on Zinnia and Cosmos sp. (De'Verennes and De'Sequeira,

1964), out of the 42 species included in the index of plant diseases caused by the powdery mildews in Portugal. Plenk et al. (1992) in Austria, reported Oidium chrysanthemi on Chrysanthemum spp., while giving a brief introduction to the biology of powdery mildews. and the symptoms caused by the fungus on host plants. In the Swiss Alps, the number of Erysiphaceae is rapidly decreasing with the increase in altitude (Blumer, 1974), some species of Erysiphe and Sphaerotheca only occur above the tree limit, anamorph stage of E. cichoracearum was reported on Hieracium aurantiacum; S. fuliginea on Aster squamatus and E. mayonii on Cirsium arvense and Cicerbita alpina for the first time.

Considerable work have been carried out on powdery mildew infecting composites in U.S.S.R. (Rud, 1939; Milovtzova, 1937: Drozdovskaya, 1980; Puzanova, 1992). Rud (1939) and Drozdovskaya (1980) have also confirmed the existence of both the organisms on different members of the family Compositae in U.S.S.R. In different parts of Ukraine, Rud (1939) studied the life history of S. fuliginea on Calendula officinalis, while Milovtzova (1937) determined E. cichoracearum f. sp. carthami on a medicinal plant (Carthamus tinctorius) from the same region. From Moscow Drozdovskaya (1980) studied specificity of E. cichoracearum to weeds and various other medicinal plants (Arctium lappa, Artemisia absinthium, Calendula officinalis, Echinops ritro, Matricaria chamomilla, Senecio rhombifolium, S. platyphylloides and Tanacetum vulgare). Akhundov (1982) from the North-East Azerbaijan reported eight genera of powdery mildews i.e. Erysiphe, Sphaerotheca, Leveillula,

Microsphaera, Phyllactinia, Podosphaera, Uncinula and Trichocladia respectively and powdery mildew fungi were found on 233 flowering plants belonging to 153 genera and 34 families, the greatest number of plants affected by these fungi belong to family Compositae (20 species). But, recently Puzanova (1992), extensively investigated powdery mildew on different plants in Krasnodarskii Kari (South U.S.S.R.) and the report revealed that 11 fungal genera with Erysiphe and Sphaerotheca are predominant among different fungi, found on 150 species, including 50 cultivated, 36 ornamental and 64 wild species. Powdery mildew infection of Sunflower is so far new and rare in this region of U.S.S.R.

E. cichoracearum have been reported on various hosts viz. Cineraria sp. (McDonald, 1939), and Zinnia sp. (Baker and Locke, 1946) from California, U.S.A. McCarter and Kays (1984), also recognized the same pathogen on Jerusalem artichokes (H. tuberosus cv. Mammoth French white) during the growing season in Georgia, U.S.A. The adaptibility and disease of Jerusalem artichoke was also reported by Laberge and Sackston (1987) in Quebec, Canada and the pathogen was identified as E. cichoracearum. The lettuce disease caused by powdery mildew (E. cichoracearum) was newly reported by Dhanvantari and Jarwis (1985) from Ontario, Canada.

In Argentina Cabrera and Mazzanti (1992) recognized S. fusca as the causal organism of powdery mildew of pot marigold (C. officinalis) and both the stages were reported to present on the host plant, the teleomorph stage was believed to be the first report

in Argentina. Diaz Franco (1985) found E. cichoracearum parasitising Sunflower in Mexico. He found that crops sown in mid March, were attacked by the pathogen, on the other hand infection failed to develop on the crops which were sown in late April.

Gorter and Eicker (1983, 1986, 1987) carried out extensive studies of the powdery mildews in South Africa. In 1983, for the first time they reported the teleomorph stage of E. cichoracearum (on Zinnia sp. and Dahlia sp.) and S. xanthii (on Bidens formosa) from South Africa. On the basis of morphological characters and germination pattern of conidia, they (Gorter and Eicker, 1986, 1987) also described six new species of Erysiphaceae i.e. Sphaerotheca fusca, S. fugax, Microsphaera begoniae, Oidium indigophera, Phyllactinia guttata and Podosphaera tridactyla which were new from South Africa. Recently, Gorter (1989) has given a classification of the Erysiphaceae with special emphasis on the anamorph characters of various powdery mildews. El-Kazzaz et al. (1992) in Egypt also carried out a similar studies in which they surveyed the powdery mildews in different parts of the Egypt on various economically important plants and taxonomically classified the family on the basis of anamorph characters. E. cichoracearum is known to infect 13 species of Chrysanthemum including C. carinatum (Blumer, 1967), Khan and Faraj (1982) reported this pathogen on C. carinatum in Libya, similarly this pathogen was also reported by several workers on different plants in Libya (Anon, 1968; Pucci 1963). While, Khan and Mussa (1979) reported its existence on Amberboa lippii in teleomorph stage. It was also

reported on Hedypnois cretica, H. polymorpha, Sonchus oleraceous, Conyza bonariensis and Zinnia elegans in Libya (Khan, 1980). S. fuliginea is reported to exist in Libya on a number of plants (Khan, 1981; Khan and Faraj, 1982), but the record of this pathogen on Bidens bipinnata is new to Libya (Khan, 1982).

In Japan Yukihiko (1975, 1980) reported E. cichoracearum on Artemisia vulgaris var. Indica maxima and Chrysanthemum boreale; S. fuliginea on H. annuus. While Hou and Lee (1981) observed S. fuliginea rather than E. cichoracearum on Dahlia pinnata in Taiwan. There are several reports of occurrence of powdery mildew from China on different members of Compositae. In 1988, Yang reported the disease of cultivated Sunflower in Liaoning province and the causal organism of this disease was identified as E. cichoracearum.

E. cichoracearum is mentioned to occur in Afghanistan, Iran, Lebanon, Nepal and Sri Lanka whereas, S. fuliginea is recognized in Turkey and U.S.S.R. Both species are, however, known to occur in Israel (Amano, 1986). Powdery mildew of Compositae in Thailand, Pakistan, Iran, Lebanon, Hongkong, Java and Mauritius is referred to as Oidium sp. (Amano, 1986), perhaps due to the lack of proper investigation in these countries. E. cichoracearum and S. fuliginea are reported to infect Compositae members in different states in India. Patel et al. (1949) reported E. cichoracearum on H. annuus from Maharashtra state. While Patwardhan (1964); Raut and Kale (1978) reported S. fuliginea as

the causal organism of Sunflower powdery mildew from the same state. Their identification is based on both anamorph as well as teleomorph characters. Powdery mildew of Safflower (C. tinctorius) caused by E. cichoracearum was reported by Saluja and Bhide (1962) in Maharashtra state. While Prasada et al. (1968) identified S. fuliginea on H. annuus as a powdery mildew pathogen from Rajasthan state. An annual ornamental plant (Dimorphotheca sinuata) was observed to be attacked by powdery mildew in Rajasthan and the pathogen was identified as S. fuliginea (Mathur et al., 1971). Jhooty (1965) from the state of Punjab identified S. fuliginea on Sunflower (H. annuus). On the basis of anamorph characters, Saxena and Saksena (1981), recognized E. cichoracearum on Dahlia variabilis from the state of Madhya Pradesh.

In 1982, Paul and Munjal reported E. cichoracearum on Artemisia scoparia and S. fuliginea on Erigeron bonariensis from the state of Himachal Pradesh. Paul and Pal (1987) from the same state found S. fuliginea var. galinsogae on Galinsoga parviflora. Powdery mildew of Inula recemosa a medicinal plant from Kashmir state was described by Narain and Saksena (1974), the pathogen on this plant was identified as E. cichoracearum when both the stages of the fungus were studied carefully.

Srivastava and Rawat (1982) reported a new disease of Anaphalis contorta from Garhwal Himalayas, Uttar Pradesh, they identified the pathogen as S. fuliginea after studying all the characteristics of the fungus. Powdery mildew on wild composite

Xanthium strumarium was recognized as Erysiphe sp. by Jain (1984) from the state of Uttar Pradesh. Recently, Perwez and Akram (1987) have recorded Vernonia cinerea, a new host for E. cichoracearum from Aligarh, Uttar Pradesh.

Leveillula taurica

The geographical distribution of Leveillula taurica on different members of the family Compositae is reported only from few countries. Its population centres in Asia, Africa and Europe. But found less frequently in Americas and occassionally in Pacific (Table 4). Seventy three genera of this family have been reported as the hosts of Leveillula from Western and Central Asia and the Mediterranean region but a least number of Compositae plants are recorded from India, Pakistan and China, chiefly on Safflower and Artichoke (in a total of 17 host genera), in the Sudan and Sub-Sahara Africa (9 genera), in the Pacific (only on Artichoke in New Caledonia), on Cynara cardunculus and three weeds (Heliopsis. Sonchus and Xanthium) in California (Palti, 1988). Occassional records were made in Europe, sometimes under glasshouse conditions. Laudanski et al. (1957), while studying on powdery mildew of Artichoke in Tunisia, found that in each pair of leaves the lower and older one are always affected before the upper and younger ones. Saad et al. (1972) in Lebanon found Safflower (C. tinctorius) crop, which were severely attacked by this pathaogen. Durrieu and Rostam (1984) reported the disease in France and distinguished it into two species of Leveillula namely L. lactucarum

and L. picridis infecting composites. Among these two L. lactucarum affects the species of Lactuca and Chondrilla. while, L. picridis parasitize the species of Picris. Leveillula mildew appear to be dynamic in nature, spreading constantly to new regions and new hosts. It also seem to increase in pathogenic intensity on certain crops. Wheather or not this is due to the introduction of new crop varieties and cultural practices. In India, L. taurica in conidial stage was first reported from Rajasthan state. Mathur et al. (1971) reported L. taurica on Tridax procumbens and Prasada et al. (1971), found it on two species of Chrysanthemum i.e. C. carinatum and C. segetum.

Perithecial formation in Leveillula is generally believed to be rather rare and the genus has mostly been reported in its conidial stage all over the world. Perithecia of L. taurica was reported by Traimer (1963) on Cynara cardunculus and on Chondrilla juncea and Picris spinulosa by Rostam (1983) in France. In Italy Ciccarone (1955) reported perithecia on C. scolymus. Beside Europe, perithecial stage of L. taurica have also been reported from Israel, Lebanon, India (Asia) and Tunisia (Africa) (Table 7). In India, Paul and Kapoor (1982) reported perithecia of L. taurica on Senecio chrysanthemoides from Kashmir state. Mathur et al. (1971) from the state of Maharashtra, recognized Leveillula taurica (Lev.) Arn. on Tridax procumbens by studying the anamorph characters of the fungus.

Oidium spp.

The anamorph (conidial) state of various powdery mildews are not uniform. They show a remarkable variation. The conidial stages provides outstanding characteristics for the differentiation of species as well as genera (Boesewinkel, 1977). There are reports of conidial stages of powdery mildew as Oidium spp. on various host plants (Braun, 1980), which clearly indicates that the species involved could not be determined. In Israel, Eshed (1975) observed Oidium type on Bellis perennis, Chrysanthemum coronarium, while Oidiopsis type on Gerbera jamesonii. Koike et al. (1988) reported Gazania as the host for Oidiopsis taurica in California, U.S.A. Grigalyunaite and Shpokauskene (1982) established the identity of 11 species of Oidium parasitising 34 species of decorative plants in U.S.S.R. Among them a type species Oidium chrysanthemi was reported on Chrysanthemum sp. Recently, Plenk et al. (1992) reported the same species on various Chrysanthemum spp. from Austria.

In India, Bhatnagar and Kothari (1966), for the first time reported Oidium xanthami on Xanthium strumarium. Oidium species has also been reported on Galinsoga parviflora and Coreopsis sp. from the state of Himachal Pradesh by Paul and Munjal (1982). Deshpande and Kore (1980), described Oidium sp. on Chrysanthemum carinatum in Maharashtra state for the first time. Various type species have also been reported in different state of India. From Aligarh, Uttar Pradesh, Perwez and Akram (1989) reported the

Oidium sp. on Gamolepis tagetes, while Singh and Singh (1977) recognized Oidium agerati on living leaves of Ageratum conyzoides from the same state.

Values of anamorph (conidial) characters in the identification of powdery mildew of Compositae

Due to infrequent findings of teleomorph (perithecial) state, the anamorph (conidial) state is taken as an especially important character. The teleomorphs have limited value in identification of powdery mildews because most collections do not contain them. Some characters of anamorph state have however, been suggested useful for identification of powdery mildews such as E. cichoracearum, S. fuliginea and L. taurica infecting different members of Compositae (Salmon, 1900; Yarwood, 1978; Boesewinkel, 1977, 1980; Amano, 1986). Characters which are considered in taxonomy of the powdery mildew on various composites are briefly given below.

Mycelium

The mycelium of E. cichoracearum and S. fuliginea is ectophytic, consisting of a network of colourless hyphae abundantly present on the surface of the infected parts of the hosts. While in L. taurica the mycelium is endophytic, spreading between the mesophyll cells of the leaves. This is a differentiating character of L. taurica from the other species. The white (hyaline or colourless) parasitic mycelium on the surface of living leaves still

distinguishes the powdery mildews from other fungi.

Conidiophores

The white powdery appearance of mildew is due to mycelium and hyaline conidia which borne on the conidiophores. The conidiophores of E. cichoracearum and S. fuliginea are unbranched or branched, bearing a chain of conidia, while those of L. taurica, it often branched with two types of conidia (navicular and cylindrical). Conidiophores of L. taurica emerge through stomata. These characters of conidiophores are useful in differentiating L. taurica from E. cichoracearum and S. fuliginea. The principal type of conidiophores are those with swollen and unswollen basal cell, twisted and untwisted basal cell, conidia borne singly or in chains, with fibrosin bodies or without fibrosin bodies and conidia of various shapes (Yarwood, 1973).

Conidia

Shape and size of conidia are believed to be utilized in taxonomy of the species (Allison, 1934; Weltzein, 1963; Clare, 1958; Jhooty, 1967).

Shape - Shape of the conidia is generally utilized to distinguish different genera of powdery mildews involved in the development of the disease. The shape of conidia of E. cichoracearum is barrel like and slightly cylindrical, whereas those

of S. fuliginea is ellipsoidal. While L. taurica produces navicular and cylindrical conidia.

Size - The size of conidia is often used in the taxonomy of powdery mildews and it is fairly constant for a given host in a given environment (Blumer, 1922). But it seems doubtful because the size of conidia are greatly influenced by temperature, relative humidity, hosts nutritional value (Zwirn, 1943) and undetermined factors (Yarwood, 1957).

Fibrosin bodies

Well developed fibrosin bodies (Zopf, 1887) occur in the conidia and conidiophores of S. fuliginea but are absent in E. cichoracearum (Ballantyne, 1963; Clare, 1964; Nagy, 1970). This character is very useful and seems to be highly reliable for distinguishing S. fuliginea from E. cichoracearum. According to Yarwood (1978), presence or absence of fibrosin bodies in conidia and their number are influenced by environmental factors, age of the host as well as the species of Sphaerotheca involved.

Germination of Conidia

Clare (1964) and Zaracovitis (1965) distinguished powdery mildews by the method of germination of the conidia. Conidia of S. fuliginea produce forked germ tubes, while those of E. cichoracearum produce simple germ tubes with well developed

appressoria. For powdery mildews, the germination of conidia is one of the few characters which can be studied apart from the host.

Identification of the pathogen in the absence of teleomorph (perithecial) state

Identification of powdery mildew of any plant in the teleomorph (perithecial) state is easy but it is rarely formed. Then identity are based on anamorph (conidial) characters. Anamorph characters of E. cichoracearum and S. fuliginea exhibit great similarities. Conidia in both the pathogens are born in long chains on same type of conidiophores. There is no distinction in symptoms of the disease caused by them on members of Compositae. This situation has great deal of confusion regarding identity of the species responsible for powdery mildew on Compositae in different parts of the world, in different areas or with in the same area in a given country.

A scheme for classification of powdery mildew based on conidial characters was proposed by Sawada (1914). The characters recognized as most useful in identification were, formation of conidia singly or in chains, shape and dimension of conidia and conidiophores, presence or absence of fibrosin bodies. Yarwood (1957) proposed that the method of germination of conidia is also a distinguishing character, though it perhaps may not be recommended for taxonomic purposes. He however, devised a key based on conidial characters for the identity of genera and species of powdery mildews in the absence of teleomorphs (Yarwood, 1973).

Boesewinkel (1977, 1980) in his key for identification of powdery mildews considered more than twelve morphological characters including presence or absence of fibrosin bodies, the size, shape and germination pattern of conidia. Ballantyne (1975). while examining, a large number of samples collected from different parts in Australia established that E. cichoracearum can be readily distinguished from S. fuliginea by utilizing conidial characters.

Conidial germination characters have been successfully adopted by various workers in differentiating powdery mildews. Hashioka (1937) and Hirata (1955) observed that S. fuliginea was unique in producing forked germ tubes. While Zaracovitis (1965) suggested to use the morphological characters of conidial germination for identifying powdery mildews. He reported that conidia of E. cichoracearum on germination produce simple germ tubes with thick walled club-shaped appressoria, whereas, those of S. fuliginea produce no well developed appressoria and a number of conidia produce forked germ tubes.

Zopf (1887), first reported fibrosin bodies from the conidia and conidiophores of Podosphaera oxyacanthae. These bodies were also regarded valuable in taxonomy of powdery mildews by Foex (1912, 1925). Bouwens (1927), Blumer (1933), and Homma (1937) considered presence or absence of fibrosin bodies valuable in distinguishing conidial stages of E. cichoracearum and S. fuliginea on different plants. Hashioka (1937), Sawada (1959), Clare (1958, 1964), Boerema and Van Kesteren (1964), Kable and Ballantyne

(1963) and Ballantyne (1963, 1975) have recognized the significance of fibrosin bodies in differentiation of S. fuliginea and E. cichoracearum.

Bouwens (1924), Clare (1958), Boerema and Van Kesteren (1964) and Jhooty (1967) considered that dimension of conidia are of taxonomic importance for these species. Yarwood (1957, 1978), however, expressed doubts about the utility of dimensions of conidia in their taxonomy as these features are greatly influenced by a number of factors including temperature, relatively humidity, host and its nutritional status. Nagy (1970) and Jhooty (1967) concluded that in general conidia of E. cichoracearum are much longer than those of S. fuliginea. Nagy (1970) used the conidial dimensions as a character of differentiation and found that the length-width ratios of the two species were significantly different, Schlosser (1976b) recommended the determination of fibrosin bodies as a standard procedure of differentiation of the two species. Sitterly (1978) suggested that conidial characters can be used for positive identification of the causal organism for the purpose of eliminating taxonomic confusion.

In the absence of perithecia, the identity of the powdery mildew of Compositae was established in a number of countries based on conidial measurements, germination rates, presence or absence of fibrosin bodies and number of fibrosin bodies per conidium. Hasan (1974) in France, Eshed (1975) in Israel, Boesewinkel (1979) in New Zealand, Braun (1980) in Germany, Khan

and Faraj (1982) in Libya, Crute and Burns (1983) in United Kingdom, Tanaka et al. (1986) in Japan have established the identity of powdery mildews on various members of Compositae on the basis of conidial characters.

Environmental relationships in the Powdery mildews

The effect of different environmental factors on powdery mildews have been extensively studied by Graf- Marin (1934). Cherewick (1944), Yarwood (1957) and Schnathorst (1965). Yarwood (1957) and Schnathorst (1965) reviewed the environmental factors on powdery mildew diseases. It was claimed that the development of powdery mildew in general was favoured by warm humid weather (Anonymous, 1946, 1950). Steiner (1908) and Tucker (1852) reported that greenhouse conditions were conducive as against out door conditions and also hot dry weather (Wager, 1937). Out of the various environmental factors, temperature and relative humidity have been reported to have a profound effect on powdery mildew development.

The cardinal temperature for germination of conidia of different strains of E. cichoracearum ranged between 5-33°C (Levykh, 1940; Deslandes, 1954; Rossouw, 1959; Schnathorst, 1960; Morrison, 1961, 1964 and Tafradzhiiski, 1963), for infection and growth of the powdery mildew it also ranged between 5-33°C (Levykh, 1940; Deslandes, 1954; Minev, 1957; Rossouw, 1957, 1959 and Schnathorst, 1960). Conidial germination of E. cichoracearum from lettuce was

highest at 18°C (Schnathorst, 1960). The cardinal temperature for infection of powdery mildew was 6-10°C (minimum), 18°C (optimum) and 27°C (maximum) respectively.

Another important environmental factor is moisture which influence the germination of conidia, infection and growth of powdery mildews. Heavy infection of E. cichoracearum on tobacco has been observed in the field at high water level. (D' Angremond, 1924). Corner (1935) reported that the conidia of E. graminis, Podosphaera leucotricha, S. pannosa and E. cichoracearum succumbed when remained in water for 1-3 hours; however, floating conidia germinated readily after 24 hours and produced straight germ tubes.

Related to the environmental factors, the more controversial aspect is relative humidity. It also plays an important role for the germination of conidia. Hashioka (1937) found that conidia of S. fuliginea from cucumber germinated between 15-18 per cent relative humidity. The survival of conidia was 14 days at 76-80 per cent, 24 days at 93-98 per cent relative humidity and for 38 days in a saturated atmosphere. Tafradzhiiski (1963) reported that conidia of the same host of S. fuliginea germinated best at 94 per cent relative humidity but they failed to germinate in drops of water.

According to Levykh (1940), there was no development of symptoms when tobacco plants inoculated with E. cichoracearum exposed to 10 per cent relative humidity at 18-19°C. However, the

symptoms appeared at 70-76 per cent relative humidity and was optimum for infection and sporulation in powdery mildew pathogens. Minev (1957), Schnathorst (1960), Morrison (1961, 1964) and Tafradzhiiski (1963) reported that the germination of E. cichoracearum from tobacco occurred slightly below the saturation. Optimum relative humidity ranged between 66-68 per cent for tobacco strains (Minev, 1957); 95.6-98.2 per cent for lettuce strains (Schnathorst, 1960) and 94 per cent for cucurbit strains (Tafradzhiiski, 1963). Germination of conidia was also observed in calcium chloride chamber at 0.1 per cent relative humidity by Morrison (1961 and 1964) and Schnathorst (1960). On the other hand, Rossouw (1959) reported the germination of conidia both at 0 and 100 per cent relative humidity. Corner (1935), Minev (1957), Morrison (1961 and 1964) and Tafradzhiiski (1963) observed that the free water inhibited the germination of conidia, while Deslandes (1954) reported that the conidia of Lettuce strains of E. cichoracearum were able to germinate in free water. Schnathorst (1960) observed that moisture stress gave highest germination of conidia of lettuce strains of E. cichoracearum. The development of powdery mildew was most affected by temperature but a atmospheric humidity influenced the rapidity and severity of disease development. Highest germination of conidia of Leveillula taurica from Cynara annuum was achieved at 100 per cent relative humidity (Clark and Ayesuoffei, 1967). At low humidity, there was only a decline in germination but a reduction in mean germ tube length. Morrison (1964) observed that the free water on leaf disc surface

inhibited the germination of conidia of large number of powdery mildew fungi but high relative humidity favoured the germination. Nour (1958) studied the effect of different relative humidities on percentage germination of conidia of various powdery mildew fungi.

It had been claimed that both infection and incidence of powdery mildews were severe under dry conditions rather than wet climatic conditions (Wager, 1937; Anonymous, 1946; Boughey, 1949; Palti, 1953). D'Angremond (1924), Blumer (1927), Deslandes (1954) and Morrison (1961) reported that high relative humidity favoured incidence of powdery mildew. Brisley (1926), Beeley (1932), Moore (1936), Fisher (1938), Bremer (1940) and Parris (1949) were also of the opinion that overhead irrigation favoured the development of powdery mildews. Schnathorst (1959) reported that the growth of mycelium was abnormal, when a film of moisture was present on the surface of epidermis. Yarwood (1939), Schnathorst (1959) and Morrison (1961), on the other hand, reported that the film of free water did not favour the development of the powdery mildews. An observation was made by Salmon (1903), Yossifovitch (1923) and Moseman and Powers (1957), that the free water was essential for the maturation of the ascospores. Disease epidemics on artichoke (H. tuberosus) was associated with limited rainfall and decreasing autum temperature, cultivars which had almost entire leaf blades and no spines, were more resistant than those with lobate leaves (Ciccarone, 1953).

Different environmental factors also influence the production of perithecia (Yarwood, 1957). Buchheim (1928) and Blumer (1948) reported that low relative humidity favoured the formation of perithecia. Similarly, Bioletti (1907) reported that generally low temperature favoured the development of perithecia in powdery mildews. On the other hand, Cherewick (1944), Arya and Ghemavat (1953) reported that in E. graminis, formation of perithecia and ascospores was favoured at alternating moderate and low temperatures. Schnathorst (1959) reported that the formation and maturation of perithecia was also a matter of time rather than cyclic changes in temperature or alternate wetting and drying. Bessey (1943) and Yarwood (1957) reported that amongst the different climatic factors, temperature appeared to be more important for perithecial formation.

Severity of powdery mildew is directly related with plant vigour and that any soil or other factor which promote plant vigourity (Arnaud and Arnaud, 1931; Smith and Blair, 1950). Trelease and Trelease (1928) and Mansson (1955) found that low nitrogen and high potassium reduced the development of mildew. Cole (1963, 1966), on the other hand reported that the plants grown in water culture fortified with all the elements which were more susceptible to E. cichoracearum, than those grown in low potassium and nitrogen level.

Host range and Host specialization

The identity and systematic position of the host plant is of help in identification, especially in case of species for which the host range is well known. The host range of many species, however, is incompletely known, due to the lack of new host recordings. A small number of species is known to have a wide host range, for example, E. polyphaga (Hammarlund, 1945) and S. fuliginea (Blumer, 1967), which occur on plants of many different and often unrelated families. L. taurica is generally thought to have a wide host range (Blumer, 1967), but Golovin (1960) divided it into 19 species which were named after the plant family on which they occurred.

While a large number of species is thought to be restricted to one or a few closely related families, the majority of species is considered to have a narrow host range (Boesewinkel, 1979a) and the identity of their host facilitates identification, especially when only one species of powdery mildew is known to occur on the host.

Powdery mildew fungi have wide host range, Salmon (1900) in his "Monograph of Erysiphaceae" listed about 1500 species as the hosts of powdery mildews. Weiss (1950) observed powdery mildews on 1340 hosts, out of 3100 host species, shown in U.S.D.A. index of plant diseases. Blumer (1967) observed powdery mildews on 1928 plant species belonging to different families of Angiosperms. Amano (1986) mentioned the host plants of powdery mildew fungi and listed 9838 Angiosperm species dispersed in 1617 genera, 169 families and

44 orders. Neither Gymnosperms nor Pteridophytes are included. The total Angiosperm species are about 220,000 in number, as calculated from A. Engler's syllabus der Pflanzenfamilien, 12th edition, 1967, the host species correspond to about 4.5 per cent of them.

The host species are divided into 9176 Dicotyledons and occupying 93 per cent of the total, while 662 plants are Monocotyledons. Among 662, 634 are members of Graminae and 28 are dispersed among seven other families.

There are three families having no host plants e.g. Aizoaceae, Theaceae and Melastomataceae. Some families having only one or a few host species e.g. Nyctaginaceae, Portulaceae, Piperaceae, Polygalaceae and Myrsinaceae. While families having many or at least several dozens of host species are also not rare. The following 19 families have more than hundred host species - Betulaceae, Boraginaceae, Caprifoliaceae, Compositae, Cruciferae, Ericaceae, Euphorbiaceae, Fagaceae, Gramineae, Labiatae, Leguminosae, Polygonaceae, Ranunculaceae, Rosaceae, Salicaceae, Saxifragaceae, Scrophulariaceae, Solanaceae and Umbelliferae. Among these famailies Gramineae, Rosaceae, Leguminosae and Compositae have 634, 694, 1022 and 1708 number of host species respectively.

Different strains of the same species may vary greatly in their host range (Schmitt, 1955). Schmitt found that the strain of Erysiphe cichoracearum on Zinnia has a greater host range than the

forms on Inula, Cerianthe, Helinathus, Phlox or Cucurbits. The great variability of E. cichoracearum is further emphasized by the findings that forms on Cucumber and Sunflower will cross infect (Reed, 1908) and sometimes will not (Schmitt, 1955). Isolates of E. cichoracearum from Sunflower, Squash, Hollyhock, Dahlia, Lippia, Picris, and Nicotiana in Berkeley, California, infected Cucumber (Yarwood, 1956), though not equally. The greatest experimental host range of a single isolate of a powdery mildew is that of E. polyphaga, which has infected 89 species in 21 families (Hammarlund, 1945).

Kenneth and Palti (1984), while studying on distribution of powdery mildews over different tribes of Compositae in Israel found that, of the numerous genera of Erysiphaceae, only Erysiphe, Sphaerotheca and Leveillula are common on hosts in the family. In addition, rare cases have been recorded of Uncinula on two host genera (Aster, Dahlia), of Microsphaera on Bidens, and of Phyllactinia on Rudbeckia. According to them, Erysiphe species attack the largest number of Compositae genera (133 genera), followed by Sphaerotheca (76 genera).

In France, Hasan (1974), studied host specialization of E. cichoracearum from skeleton weed, Chondrilla juncea. Plant species comprising a number of cichoraceous plants closely related to Chondrilla, and cultivated plants belonging to 23 families particularly including the cultivated Compositae, Cucurbitaceae, Solanaceae and Leguminosae, on which forms of this fungus have

been recorded, were inoculated with conidia of the mildew. Moreover, three cultivars of all cultivated species recorded as hosts of any form of E. cichoracearum were tested. The powdery mildew from C. juncea did not develop on any of these plants. Yukihiko (1975), in Japan carried out a similar experiment in which isolate of E. cichoracearum from Artemisia vulgaris var. Indica Maxima cannot parasitize A. japonica, whereas, isolate of S. fuliginea from Impatiens balsamina infects H. annuus. Tanaka et al. (1986) studied on powdery mildew of Carthamus tinctorius which was found for the first time in North Japan. The causal organism was identified as S. fuliginea and was proved by inoculation experiments to be virulent to Arctium lappa beside Carthamus tinctorius, out of 27 host species of different families which were inoculated.

Cross inoculation experiments between species of three genera in the family Compositae have been carried out by Rostam (1983). Inoculum from Picris spinulosa, Chondrilla juncea and Lactuca viminea was inoculated on each of these hosts, but in every case only the original host was infected. The inoculum from L. viminea also failed to infect two other species of Lactuca. Successful interspecific cross-infection between Cynara scolymus the artichoke and C. cardunculus has been carried out by Ciccarone (1955) and Traimer (1963). As regards inter family cross infection, it is apparent, that inoculum from Compositae hosts of Leveillula is capable of infecting plants in the Solanaceae (Capsicum sp., Lycopersicum sp.) and Leguminosae (Onobrychis sp.). Of special

practical importance is the potential of Leveillula inoculum from artichoke to infect pepper; this has been demonstrated to be the case in France (Traimer, 1963), but cross-infection between these hosts have failed in Italy (Ciccarone, 1955) and in Lebanan (Saad et al. 1972).

Varietal resistance

Control of powdery mildews by resistant varieties (cultivars) has been as successful and also as disappointing as the control of other disease by this means. Varieties of grape (Arnaud and Arnaud, 1931), wheat (Mains, 1934), bean (Dundas, 1941) and many other crops, resistanat to mildew are known, and hydridization to incorporate resistance into new and commercial cultivars is extensive. Sometimes a resistant variety suddenly becomes susceptible, and the explanation is usually that a new strain of the pathogen has appeared (Jagger et al. 1938). The mechanism of the origin of new parasitic strains of powdery mildews is little understood, but presumably the problem is the same with mildews as with other plant pathogens (Christensen and Daly, 1951). Resistance to powdery mildew has been invariably corelated with frequency of hairs on plant parts and with high osmotic pressure of the cell sap (Homma, 1937). It is an attractive hypothesis that resistance to powdery mildew, or to any other plant pathogen, depends upon the presence in the resistant plant of specific chemicals which are toxic to the pathogen. Most of the plants are resistant to mildews as well as to most other pathogens, but

resistance to one pathogen is not well established with resistance to another. Since 1950, Schnathorst and colleagues have worked extensively on E. cichoracearum infecting lettuce in California, U.S.A. The pathogen strain responsible for outbreak on cultivated lettuce (L. sativa) since 1951, is physiologically distinct from the Salinas valley wild lettuce strain, it is pathogenic to the cultivated lettuce varieties. Infection have occurred in most years since 1951. in some instances leading to severe damage (Schnathorst et al., 1958). Blumer (1933) cited two outbreaks in Europe (1913 and 1914) but only the Oidial stage was seen. In U.S.A. the disease is now spreading North and South of the Salinas valley and may have reached Arizona (Snyder et al. 1952). Anon (1960) reported the disease in Michigan, while Chorin and Palti (1962) in Israel and Hirata (1966) cited the disease in France, Greece, Switzerland and the U.S.S.R. Susceptibility in cultivars of Lactuca spp. was described by Schnathorst and Bardin (1958), none of the crisphead or non heading leafy types were resistant and only butterheads such as Arctic king, Big Boston, Salad Bowl and Bath Cross possessed resistance.

In Tunisia, Laudanski et al. (1957) studied, artichoke crop which incurs most severe losses from the attack of Leveillula mildew,may suffer pronounced reduction in the size of the plant as well as the quality of its yield, especially where the crop is held over for a second season, but there are considerable differences in the susceptibility of various cultivars.

A number of cultivars of different Compositae members are grown in different parts of the world including India. New cultivars are regularly bred and introduced for commercial cultivations. Since the response of different cultivars of Compositae to different species of powdery mildew are likely to be variable, so, it is essential to know the occurrence of species of powdery mildew in a given area for successful cultivation of various plants of the family Compositae vulnerable to attack by powdery mildews.

Chemical control

The serious economic damage due to powdery mildews may be manifested as direct fall in yield, as a suppression or distortion of plant growth, as spoilage of fruits or as disfigurement of ornamental plants which in longer terms affects the yield. To make plants free from powdery mildews various types of fungicides are in continuous use. Because of their superficial position on plants, powdery mildews can be more readily controlled than can most parasitic fungi (Yarwood, 1973). The first serious attempts to stop damage caused by powdery mildews were probably made in the early nineteenth century, when sulphur dusting came into use for the control of mildew on fruit trees. Since than the usage of fungicides against powdery mildews has increased enormously. Crosier and Szkolnik (1956) found that fungicidal control was greater on weak than on vigrous host plants.

The value of other methods of control, such as planting resistant cultivars, pruning and burning mildewed shoots, and removing volunteer host plants, has also been increasingly recognized. However, it is the application of chemicals, that forms the principal defence against powdery mildews throughout the world.

Powdery mildews can thus be controlled by protective, eradicant and therapeutic applications. Usually the same fungicide can act in all three ways from the same application. For example, when sulphur dust is applied to control grape powdery mildew, it will kill spores which are already present but which have not caused infection (eradication), it will kill spores which subsequently arrived on the dusted vines (protection), and will kill the mycelium of established infections (therapy).

In India, the powdery mildew has been reported to occur every year on different members of the family Compositae and cause enormous losses to ornamental plants. Various workers reported the effect of different fungicides like Karathane EC (48 per cent 1-methyl-heptyl) phenylcrotonate, Bavsitin (50 per cent 2-methoxy-carbamoyl) benzimidazole) and Morestan (25 per cent 6-methyl-quinoxaline-2, 3. dithiocarbonate) on different plants mostly other than Compositae. Pathak and Joshi (1972) found Karathane to be most effective than Morestan in controlling powdery mildew of wheat, Erysiphe graminis tritici. Similar results were obtained by Gupta et al. (1975) in controlling Erysiphe polygoni DC. causing powdery mildew of moong (Phaseolus aureus Roxb.) and

by Srivastava et al. (1973) in controlling E. polygony on pea. Nema and Krishna (1982), also found Karathane highly effective against E. polygoni, beside Sulfex (0.05 per cent) and Calixin (0.05 per cent), while controlling the disease on pea.

The powdery mildew disease is being controlled by chemical fungicides in the absence of suitable resistant cultivars. Recently, a few commercial fungicides, e.g. Calixin, Sulfex, Karathane, Bavistin, Morestan, Cosan and Elosol, are used for the control of powdery mildews and have shown promising results (Pathak and Joshi, 1972; Gupta et al., 1975; Srivastava et al., 1973).

MATERIALS AND METHODS

The different materials used and methods employed during the present studies are given below:

Survey and Collection

Survey was conducted in various localities in some districts of Uttar Pradesh to determine the severity (intensity) of powdery mildews on different members of the family Compositae. Various localities of districts like Agra, Aligarh, Allahabad, Bareilly, Budaun, Bulandshahr, Etah, Etawah, Kanpur and Mathura in Uttar Pradesh (India) were surveyed to establish the identity of powdery mildew species infecting composites. Different plants which were found during the course of survey are as follows:

1. Acroclinium spp.
2. Calendula officinalis Linn.
3. Chrysanthemum coronarium Linn.
4. Cineraria spp.
5. Coreopsis spp.
6. Cosmos sulphureus Cav.
7. Dahlia variabilis Desf.
8. Dimorphotheca sinuata DC.
9. Eclipta alba (Linn.) Hassk.
10. Helianthus annuus Linn.
11. Xanthium strumarium Linn.
12. Zinnia elegans Jacq.

Ten to twenty samples of each of the aforesaid plants found during the surveys were collected at random from each of the available garden or field in a locality. Aerial parts of the plants (leaves, stems, twigs and flowers etc.) comparised the samples. Each sample was then packed seperately in polythene bags, marked properly and brought to the laboratory. All the samples which were collected, closely examined for studying the characteristics of the symptoms on plant parts.

Incidence of disease (per cent occurrence) on each member of Compositae in a localaity was calculated as per the method given by Johnston and Booth (1983), which is as follows :

$$\text{Incidence (\%)} = \frac{\text{Number of infected plant units}}{\text{Total number (healthy \& infected) of units assessed}} \times 100$$

Severity (intensity) of disease on different composites in different localities of the districts was rated as under:

No infection	(-)	=	No visible disease symptoms.
Mild infection	(+)	=	Patches few, small in size and scattered.
Moderate infection	(++)	=	Patches many, large in size tending to coalesce.
Severe infection	(+++)	=	Large patches covering almost the entire leaf area.

Average of the ratings from different places of a particular locality was assigned as severity grade to each plant of Compositae in that locality.

Identification of the causal organism

Identity of the powdery mildew species infecting various plants in different localities of the districts were established by using anamorph (conidial) characters. Since teleomorphs (perithecia) develops rarely on Compositae, so, anamorph characters were taken into consideration for the identity purposes. Anamorph characters of the powdery mildew species in each sample were studied microscopically. These characters include, colour of the mycelium in older patches (Yarwood, 1957); shape of the conidia (Alcorn, 1968); conidial size (Bouwens, 1924, 1927; Boesewinkel, 1980); presence or absence of fibrosin bodies (Homma, 1937; Kable and Ballantyne, 1963; Jhooty, 1967; Yarwood, 1978) and type of germ tubes produced (Hirata, 1942, 1955; Zaracovitis, 1965).

The following anamorph characters were studied:

1. Mode of parasitism in relation to ectophytic and endophytic nature of the mycelium.
2. Morphology of conidiophores in relation to branching.
3. Shape of conidia.
4. Dimensions of conidia (length & breadth).
5. Length/breadth (L/B) ratio.

6. Presence or absence of fibrosin bodies in conidia.
7. Mode of germination of conidia and type of the germ tube produced.
8. Development of appressoria.

For measurements, the conidia from different collections were stained in cotton blue and mounted in lactophenol. In each case 100 conidia were measured with the help of ocular micrometer. The differences in the size of the conidia was statistically analysed to find out the morphological difference, if any. L/B ratio was also determined by dividing length of a conidium with its breadth. For fibrosin bodies and type of the germ tubes produced, fibrosin bodies test and germination test were performed.

Fibrosin bodies test

Conidia from each sample were tested for the presence of fibrosin bodies. These were gently dusted on clean dry glass slides from different samples. Than, a few drops of 3% KOH (potassium hydroxide) aqueous solution was added on each slide (Kable and Ballantyne, 1963). While examining conidia under the microscope, following observations were made:

1. Presence or absence of fibrosin bodies.
2. Per cent occurrence of conidia with fibrosin bodies.
3. Number of fibrosin bodies per conidium.

Germination test

Similarly, for germination conidia were gently dusted on clean dry glass slides from different leaves or other aerial parts of the samples. These slides were placed on glass - rod triangle, kept in petriplates containing sterilized distilled water at the bottom. The petriplates were incubated at 20°C (± 2) for 24 hours. After incubation period these slides were examined under the microscope. For each observation 80 conidia from each slide were selected at random in different microscopic field, following observations were made for the germ tubes produced.

1. Per cent conidial germination.
2. Per cent forking of germ tubes.
3. Point of origin of germ tube on the conidia.
4. Presence or absence of appressoria at the tip of the germ tubes.

Culture and maintenance of powdery mildews

Inoculum of E. cichoracearum and S. fuliginea from selected samples and areas of high disease intensities and different districts were maintained on their respective hosts in separate glasshouse chambers at 20°C (± 2), so that the inocula should not be mixed. Inoculations were made by dry dusting of conidia or appressing infected leaves on the surface of leaves of the seedlings. Subsequent inoculation when found necessary, were made to maintain the inocula for desired length of time.

Consistency in anamorph characters

To ascertain consistency in the conidial characters in order to use them as basis for identification of E. cichoracearum and S. fuliginea, dimensions of conidia (length, breadth and L/B ratio), presence and absence of fibrosin bodies, per cent occurrence of fibrosin bodies, per cent conidial germination, point of origin of germ tubes on conidia, morphology of germ tubes, per cent forking of germ tubes and development of appressoria in various samples of Compositae, infected with powdery mildews were studied. Data so obtained were than assessed for their taxonomic value for identification of the speices.

Host range studies

For the host range studies, twenty cultivated and seven wild plants of the family Compositae and eighteen plants of different families (Table 9) were selected. These plants were grown in 15 cm clay pots filled with autoclaved field soil, sand and farm manure (3:1:1). Some wild host plants naturally infected in the field were uprooted and transplanted in the pots for experimental purpose. For the inoculation of potted plants, plants of 3 different ages (2 week, 3 week, 4 week old) were used.

These plants were inoculated with E. cichoracearum and S. fuliginea. The isolates of these pathogen were obtained from Cosmos sulphureus, Chrysanthemum coronarium, Dahlia variabilis, Zinnia elegans for E. cichoracearum and Cineraria sp., Calendula

Table 9

List of some composites and non-composites tested against powdery mildew pathogen

Cultivated composites	Wild composites
1. Acroclinium sp.	1. Ageratum conyzoides Linn.
2. Arctotis sp.	2. Conyza japonica (Thunb.) Less.
3. Aster sp.	3. Eclipta alba (Linn.) Hassk.
4. Brachycome iberidifolia Benth	4. Sonchus oleraceous Linn.
5. Calendula officinalis Linn.	5. Tridax procumbens Linn.
6. Carthamus tinctorius Linn.	6. Vernonia cinerea (Linn.) Less.
7. Centaurea moschata Linn.	7. Xanthium strumarium Linn.
8. Cosmos sulphureus Cav.	
9. Chrysanthemum coronarium Linn.	
10. Cineraria sp.	
11. Coreopsis sp.	
12. Dahlia variabilis Desf.	
13. Dimorphotheca sinuata DC.	
14. Gaillardia sp.	
15. Gazania splendens Hort.	
16. Helianthus annuus Linn.	
17. Helichrysum bracteatum Andr.	
18. Lactuca sativa Linn.	
19. Tagetes erecta Linn.	
20. Zinnia elegans Jacq.	

Non-composites	Family
1. Abelmoschus esculentus (Linn.) Moench.	Malvaceae
2. Benincasa hispida (Thunb.) Cogn.	Cucurbitaceae
3. Cassia occidentalis Linn.	Leguminosae
4. Capsicum annuum Linn.	Solanaceae
5. Chenopodium ambrosioides Linn.	Chenopodiaceae
6. Coriandrum sativum Linn.	Umbelliferae

Contd.

Table 9 (Contd.)

7.	Coccinia cordifolia Cogn.	Cucurbitaceae
8.	Cucurbita maxima (Duch.) Poir	Cucurbitaceae
9.	C. moschata (Duch.) Poir	Cucurbitaceae
10.	Cucumis melo Linn.	Cucurbitaceae
11.	C. sativus Linn.	Cucurbitaceae
12.	Daucus carota Linn.	Umbelliferae
13.	Euphorbia hirta Linn.	Euphorbiaceae
14.	Foeniculum vulgare Mill.	Umbelliferae
15.	Impatiens balsamina Linn.	Balsaminaceae
16.	Lagenaria leucantha (Duch.) Rusby.	Cucurbitaceae
17.	Lycopersicum esculentum Mill.	Solanaceae
18.	Nicotiana tabacum Linn.	Solanaceae

officinalis, Dimorphotheca sinuata, Helianthus annuus for S. fuliginea. These isolates were arbitrarily designated as Cs, Cc, Dv, Ze, and Ci, Co, Ds, Ha respectively.

Inoculated plants were kept in separate glasshouse chambers. For field trials, inoculated seedlings were transferred with entire soil to the pits, dug earlier at a distance of 20-30 ft. Healthy seedlings were also transferred for control. And in the glasshouse each replicate of every plant was also used as control. Five replicates were made for each host parasite combination. Inoculated plants were regularly examined for the appearance of the disease and host response was examined after ten days of inoculation as under:

Resistant (R) = Mildew fail to appear

Susceptible (S) = Mildew appear

Varietal resistance

Ninety nine cultivars belonging to seventeen genera of the family Compositae were screened for varietal resistance (Table 10). These cultivars were inoculated with Cs, Cc, Dv and Ze isolates, which were obtained from Cosmos sulphureus, Chrysanthemum coronarium, Dahlia variabilis and Zinnia elegans respectively.

The commercial packets containing cultivar of mixed and hybrid mixed seeds made confusion about the homogeneity and heterogeneity of the germplasm. To avoid such confusion, the seeds

Table 10

List of different cultivars tested against powdery mildew pathogen

Composites	Cultivars
Acroclinium sp. (3)	Semi double white pink, Splendens mixed, Special mixture.
Arctotis sp. (3)	Hybrid mixed, Special hybrid, Grandis hybrid.
Aster sp. (6)	Giant mixed, Double mixed, Ostrich plume white, Crego giant mixed, Teisa stars mixed, Powder puff mixed.
Calendula officinalis (7)	Double golden emperor, Double geisha girl, Kelmscott giant orange, Double mixed, Orange king, Pacific beauty mixed, Fiestive gaurd.
Carthamus tinctorius (1)	Kusumika.
Chrysanthemum coronarium (4)	Maxima may queen, Annual mixed, Selection mixed, Coronarium mixed.
Cineraria sp. (3)	Maxima mixed colours, Duplex double flowers, Early spring glory.
Cosmos sulphureus (8)	Sensation mixed, Choiced mixed, Goldcrest, Sunset, Bright lights, Candy stripe, Early flowering mixed, Double crested mixed.
Coreopsis sp. (5)	Flowers all the year round, Dwarf double sunburst, Early sunrise, Sunbeam, Tall mixed.
Dahlia variabilis (7)	Collasal single mixed, Dwarf double redskin, Coltless hybrid mixed, Dwarf border mixed, Unwins bedding, Decorative mixed, Exhibition mixed.
Dimorphotheca sinuata (4)	Orange, Special mixture, Giant orange, Glistening white.

Contd.

Table 10 (Contd.)

Gaillardia sp. (5)	Mixed, Grandiflora mixed, Picta lollypop orange, Picta lollypop yellow, Picta lollypop mixed.
Gazania splendens (3)	Sunshine hybrid mixed, Hybrid mixed, Local.
Helianthus annuus (9)	Double sungold tall, Miniature mixed, Japanese miniature mixed, Brown fancy mixed, Giant russian, Local (a), Local (b), Single tall yellow, Mammoth russian.
Lactuca sativa (5)	Green and paris white, Wayahead, Avoidefiance, Black seeded simpson, Local.
Tagetes erecta (13)	Dwarf double rusty red, Dwarf double harmony, Dwarf double mixed, Spanish brocade, Lemon king, Naughty marietta, Susanna, Trinity inca orange, Trinity inca gold, Tall african mixed, French dwarf mixed, Local (a), Local (b).
Zinnia elegans (13)	Cerise queen, Purity, Violet queen, Giants of california mixed, Canary bird, Crimsom monarch, Rich salmon rose, Ruffled jumbo mixed, Linearis white, Golden dawn, Purple prince, Dahlia flowered mixed, California giant mixed.

Figures in parenthesis indicate the number of cultivars tested.

of these cultivars were sown seperately and isolated at three lines on the basis of difference in colour of the flowers. The seeds were collected separately and sown in subsequent generation to have the pure lines. During varietal screening, three lines of mixed and hybrid mixed were inoculated separately and observed that all the three lines gave similar response against the pathogen, irrespective of the colour of the flowers, that is why these lines were not mentioned separately in the results. Inoculated plants were transferred to the glasshouse benches as well as in the field as described earlier.

Observations of disease intensity were made daily for two weeks or so after inoculations. Different cultivars were placed in various categories of resistance and susceptibility on the basis of type of reaction as suggested by Mains and Deitz (1930) with some modifications as follows:

Grade	Description	Infection rating
Highly resistant	(Macroscopically no mycelium is evident)	0
Resistant	(Trace to slight development of fungus evident macroscopically)	1
Susceptible	(A moderate development of fungus occurs accompanied by moderate sporulation)	2
Highly susceptible	(Abundant fungal growth is developed accompanied by abundant sporulation)	3

Chemical control

Seeds of the susceptible Dahlia variabilis (cv. Decorative mixed) cultivar were sown in 15 cm clay pots filled with autoclaved field soil, sand and farm manure (3:1:1). Seedlings were dusted with conidia of E. cichoracearum 15 days after emergence. The plants were 15-25 cm long having 6-10 leaves. The plants were sprayed with different concentrations (0.001, 0.01, 0.1 and 0.2 per cent) of three fungicides viz. Karathane EC (48 per cent 1-methyl-heptyl) phenylcrotonate, Bavistin (50 per cent 2-methoxy-carbamoyl) benzimidazole) and Morestan (25 per cent 6-methyl-quinoxaline-2, 3. dithiocarbonate). The sprays being applied with the help of a hand sprayer seven days after spore dusting. The pots were incubated in a glasshouse at 20°C(±2) at 90 per cent relative humidity. During this period visible colonies of powdery mildew were observed on the inoculated plants. Similarly, the control plants were sprayed with water. For each treatment, three replicates were maintained. The spraying was done thrice at an interval of 15 days. The percentage of leaf infection was recorded by randomly taking five plants from each treatment. All the leaves were counted and percentage leaf infection was calculated on the basis of leaves infected at 7 days intervals after first, second and third sprayings. The percentage disease index and percentage disease control was calculated by adopting the following formula:

$$\text{Percentage disease index (PDI)} = \frac{\text{Total rating}}{\text{Total number of leaves examined} \times \text{Maximum rating}} \times 100$$

$$\text{Percentage disease control (PDC)} = \frac{\text{Disease index in control} - \text{Disease index in treatment}}{\text{Disease index in control}} \times 100$$

Statistical Analysis

The data obtained after measurement of dimensions (length, breadth and L/B ratio) of conidia, per cent occurrence of conidia with fibrosin bodies, number of fibrosin bodies per conidium, per cent germination and forking/non-forking of conidia were analysed statistically. The significant difference, if any, in the length and breadth of conidia collected from various districts was studied at 5% level of significance (Panse and Sukhatme, 1989).

State of Uttar Pradesh - Geographical Position and Climate

The state of Uttar Pradesh is situated in the Northern part of India between 23° 52'N and 31° 18'N, and 77° 10'E and 90° 39'E and covers an area of about 2,93,963 square kilometres. It is bounded by Tibet and Nepal on the North; Himachal Pradesh on the North-East; Punjab and Haryana on the West; Rajasthan on the South-West; Madhya Pradesh on the South and Bihar on the East (Fig.1). Except for a few areas, the entire state is a vast, verdant plain watered by rivers like Ganga, Yamuna and Ghagra and a number of smaller streams, besides a network of Canals and Tubewells.

The general climate of this region is warm and dry. Mean monthly temperature varies considerably throughout the year. The mean maximum temperature being 24.8°C from January to March and minimum 10.5°C. Mean maximum temperature from April to June remains 38.4°C and minimum 24.1°C, being maximum from July to September 32.2°C and minimum 25.6°C, and from October to December remains 26.7°C and 13.1°C respectively.

The relative humidity during the winter season i.e. from November to December ranges from 63-71 per cent in the morning and 28-45 per cent in the evening. But during summer season, it declines considerably and remains 29-37 per cent in the morning and lowers down to 16-21 per cent in the evening. On the onset of monsoon the relative humidity increases and reaches its maximum in

August i.e. 69-87 per cent in the morning and 57-78 per cent in the evening.

The districts included in these studies are situated in the sub-tropical region and its climate can be said to be of sub-tropical monsoon type. It is said that "Seasonality is the keynote of Indian climate" and the three seasons - the rainy, the cold and the hot-are well marked off. The first commences with fair regularity in the middle of June and continues till the end of September, but as the monsoon from the Bay of Bengal sweeps over the Uttar Pradesh, the commencement of the rainy season may be as early as the begining of June or as late as the first or second week of July. The cold weather extends from early October to the end of February. March is transitional month. The third season extends over the remaining months of the year. In this season the temperature begins to rise, and so it gradually merges into the hot weather with high temperature and dry westerly winds. A statement regarding the temperature and relative humidity of the surveyed districts, during the months, when powdery mildew disease on composites was studied is given in Table - 11 (a & b) for each district to have a cursory idea about the prevailing temperature and relative humidity fluctuations during the present studies.

Table 11(a)

Fluctuations in Temperature recorded from the surveyed districts during 1992, in the months when powdery mildew disease was observed

District	Temperature (°C)											
	January		February		March		October		November		December	
	a	b	a	b	a	b	a	a	a	b	a	b
Agra	7.4	22.2	9.1	25.7	15.7	31.9	18.2	33.0	12.0	29.2	8.0	24.1
Aligarh	8.1	20.7	10.4	23.7	13.2	30.0	16.9	30.8	11.0	28.0	7.0	22.0
Allahabad	9.6	25.1	12.7	29.5	18.6	34.7	19.5	34.9	13.8	30.1	10.4	27.2
Bareilly	6.8	21.3	9.8	24.0	14.9	29.6	18.9	32.1	12.1	27.7	7.3	23.0
Budaun	8.5	23.0	11.0	27.9	16.8	34.2	20.3	30.8	13.5	24.9	9.9	24.0
Bulandshahr	7.0	20.9	8.3	25.1	13.4	30.8	17.2	30.6	10.2	28.0	7.7	21.3
Etah	8.4	23.8	10.8	25.9	15.9	32.7	19.2	33.1	12.2	28.0	8.5	24.4
Etawah	9.7	24.0	11.5	27.2	17.0	30.3	21.0	32.7	14.2	30.5	9.5	25.5
Kanpur	7.8	22.8	11.8	28.2	16.2	33.8	20.3	36.8	13.5	28.9	9.2	26.5
Mathura	8.6	23.9	12.1	26.6	18.2	35.3	29.5	32.2	11.2	27.4	7.3	22.3

a = Mean daily minimum; b = Mean daily maximum.

Table 11(b)

Variations in Relative Humidity recorded from the surveyed districts during 1992, in the months when powdery mildew disease was observed

District	Relative Humidity (%)											
	January		February		March		October		November		December	
	a	b	a	b	a	b	a	b	a	b	a	b
Agra	45	73	32	64	24	47	40	59	33	61	40	68
Aligarh	47	75	37	67	26	51	38	62	34	58	43	70
Allahabad	39	65	28	54	18	37	35	65	32	51	38	60
Bareilly	54	81	45	75	30	59	45	73	45	70	51	80
Budaun	50	73	38	58	32	49	50	64	39	51	48	63
Bulandshahr	46	70	42	78	34	64	49	76	54	81	53	78
Etah	47	81	43	71	25	51	58	72	53	73	54	80
Etawah	53	82	53	74	38	57	61	75	54	69	60	84
Kanpur	48	79	38	78	26	46	48	68	42	67	45	77
Mathura	52	75	42	70	29	48	55	70	46	65	52	71

a = RH at 8.30 morning; b = RH at 5.30 evening

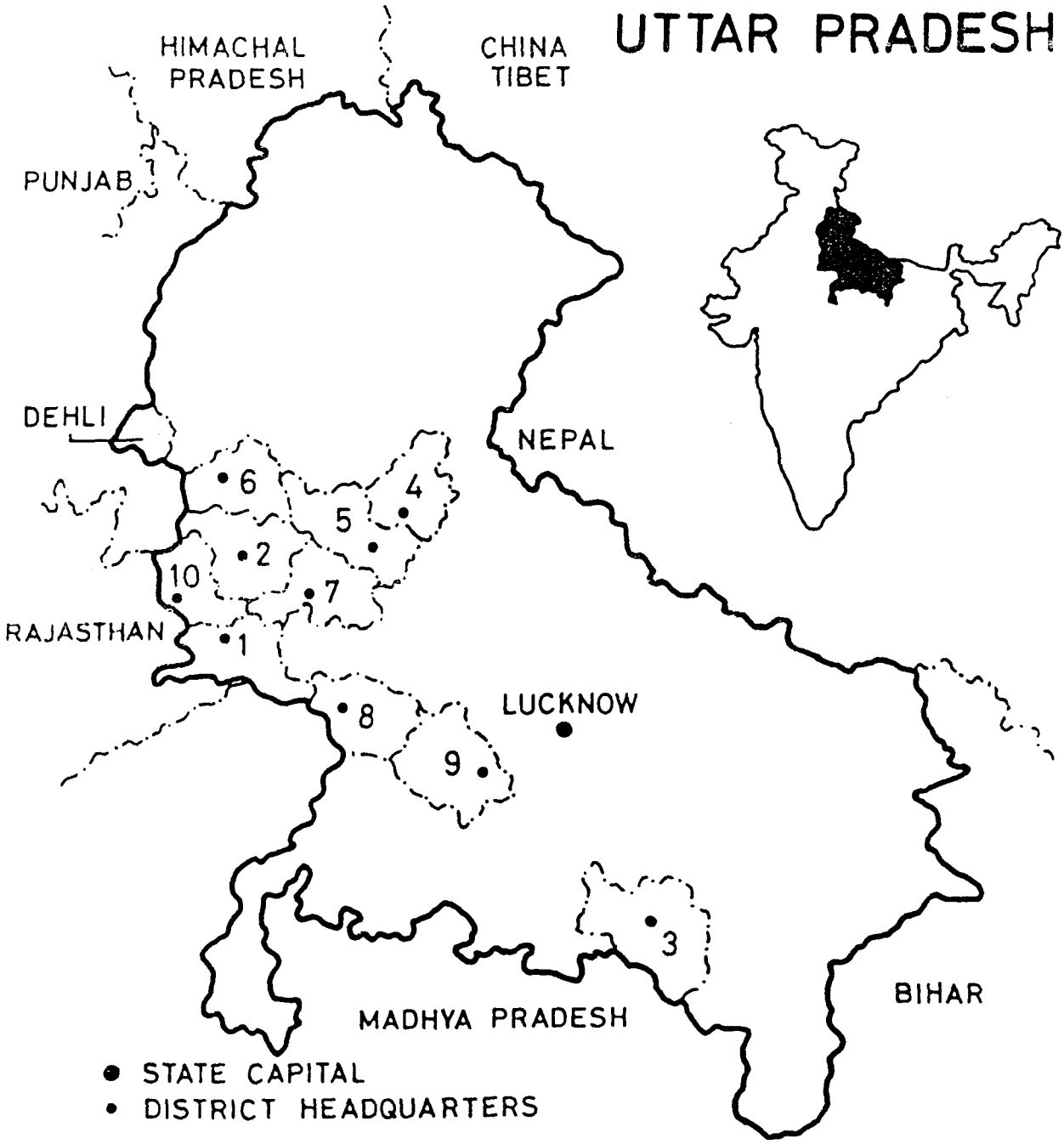
RESULTS

Identification of powdery mildew species

Surveys were conducted to determine severity and identity of powdery mildew species attacking different members of the family Compositae in the districts of Agra, Aligarh, Allahabad, Bareilly, Budaun, Bulandshahr, Etah, Etawah, Kanpur and Mathura (Fig.1). The species of powdery mildew associated with different plants in various districts were identified by using anamorph (conidial) characters.

Symptoms

White fluccose circular powdery patches were invariably present on leaves and stems of infected plants. These patches were scattered in few samples. Irregular patches were mostly present on the underside of the leaves and elongate patches on the stems (Plate I , Fig. A). These patches gradually turned light brown becoming flocculent. In some plants the infected areas were not discoloured, but occasionaly dries in the later stage and turns yellow, as observed in few cases. While in some plants sparse inconspicuous growth on the lower surface of leaves with a slight irregular discolouration of affected parts was observed. In case of severe infection entire foliage was covered with powdery mass. In some plants during survey, flowers and buds were also found covered with powdery mass such as Cosmos sulphureus and Dahlia



1. AGRA
2. ALIGARH
3. ALLAHABAD
4. BAREILLY
5. BUDAUN
6. BULANDSHAHR
7. ETAH
8. ETAWAH
9. KANPUR
10. MATHURA

FIG 1. DISTRICTS OF UTTAR PRADESH INCLUDED IN THE SURVEY.

variabilis (Plate I , Fig. A&B).

Anamorph characters

Colour of the mycelium was greyish white, septate and profusely branched. In some samples the mycelium was observed as cottony white and it was ectophytic in nature and well developed. Conidiophores erect, simple and unbranched and septate conidia borne on the conidiophores in chain. Colour of the conidia was hyaline. Shape of the conidia varies among different samples, in some, conidia were ellipsoidal, while in others cylindrical and barrel shape conidia were observed.

The details of the incidence and intensity and the identity based on conidial dimensions, L/B ratio, fibrosin bodies and germination tests of powdery mildew species are given below seperately for each district.

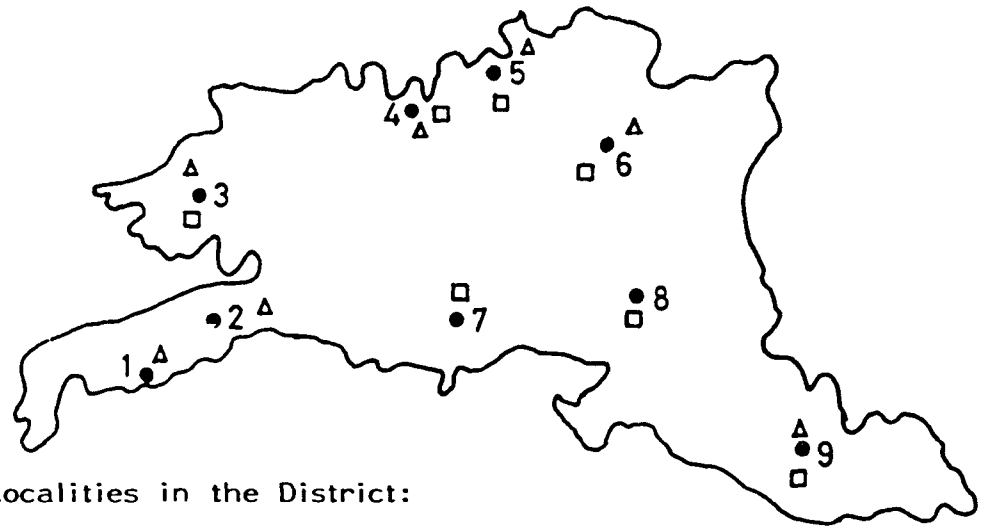
District : Agra

Different localities in this district were surveyed in the first week of November, 1991 (Fig. 2) and found the disease on composites like Acroclinium spp., C. officinalis, C. sulphureus, Cineraria spp., Coreopsis spp., D. variabilis, E. alba, H. annuus, X. strumarium and Z. elegans. (Table 22). All the infected cultivated composites were found in bungalow gardens and public parks, while the wild composites were observed at the road sides and fields. These plants were invariably found infected with powdery mildew

DISTRICT: AGRA

Area- 4816 sq.km

0 25
KM



Localities in the District:

1. Jagner
2. Sarendhi
3. Fatehpursikri
4. Runakata
5. Khandauli
6. Tundla
7. Iradatnagar
8. Fatehabad
9. Jetpur

△ Erysiphe cichoracearum

□ Sphaerotheca fuliginea

FIG.2 DISTRIBUTION OF POWDERY MILDEW IN DISTRICT AGRA.

and showed a varying degree of disease intensity (Table 17). The severity of the disease on C. sulphureus, D. variabilis, H. annuus and X. strumarium was high. The disease incidence was 70 per cent on Acroclinium spp., D. variabilis and X. strumarium, while 73 per cent on C. sulphureus. On other composites it was below 60 per cent (Table 12).

The mean conidial dimensions measured from Acroclinium spp., Cineraria spp., C. officinalis, Coreopsis spp., C. sulphureus, D. variabilis, E. alba, H. annuus, X. strumarium and Z. elegans were 35.032 X 16.232 µm, 33.875 X 18.326 µm, 29.000 X 15.125 µm, 27.765 X 13.825 µm, 30.860 X 15.125 µm, 37.621 X 18.215 µm, 31.223 X 13.728 µm, 28.040 X 15.372 µm, 35.365 X 14.312 µm and 33.712 X 16.085 µm and the mean L/B ratios determined were 2.10, 1.81, 1.86, 2.05, 2.00, 2.20, 2.26, 1.93, 2.18 and 2.08 respectively (Tables 23-32).

For the fibrosin bodies test 407 samples were examined, out of these, 104 contain few conidia without fibrosin bodies while in the remaining 303 samples fibrosin bodies were present in all the conidia (Table 33, Fig. 12). The mean per cent occurrence of conidia with fibrosin bodies from these samples was 89.92 and mean number of fibrosin bodies per conidium 7.39 (Table 34, Fig. 13,14). Well developed, discrete and different shapes of fibrosin bodies were invariably present in the conidia of powdery mildew collected from Cineraria spp., C. officinalis and H. annuus. The mean number of fibrosin bodies per conidium in these plants observed

were 6.86, 7.23 and 8.10 respectively, while the range of fibrosin bodies per conidium varies from 5 to 12 (Table 35, Fig. 15).

On germination, conidia from different composites produce simple and forked germ tubes. These germ tubes emerged from the side walls of the conidia. The mean per cent germination for S. fuliginea and E. cichoracearum was 73.67 and 80.13 and per cent forking of the germ tubes was 56.36 (Table 36, Fig. 20,21). Conidia of E. cichoracearum did not contain fibrosin bodies and on germination produced simple germ tubes (non forked) with well developed appressoria at the tip of germ tubes. The germ tubes emerged apically/basally of the conidia.

Severely infected Chrysanthemum coronarium was also found in three localities (Fatehpursikri, Tundla and Fatehabad) of this district. Anamorph stage of the pathogen was present. Colour of the mycelium was greyish white and mean conidial dimension measured 33.785 X 14.366 µm, mean L/B ratio was determined 2.18. Conidia were devoid of fibrosin bodies and on germination produced straight germ tubes. On the basis of aforesaid characters it can be concluded that the causal organism of the above host was E. cichoracearum.

District : Aligarh

Nine localities in this district were surveyed in the last week of October, 1991 and again in the first week of December, 1992

(Fig 3). The localities surveyed and composites encountered are given in Table-22. Two wild composites viz. Eclipta alba and Xanthium strumarium were invariably found infected with powdery mildew. While rest of the cultivated composites remains the same. The disease intensity on different composites showed a variation among the localities. Table-17 clearly indicate that highest disease intensity was recorded on C. sulphureus and D. variabilis, but in the other localities infection was mild to moderate. The incidence of disease was recorded 70 per cent on Acroclinium spp., C. sulphures and D. variabilis but below 55 per cent on other composites (Table 12).

Conidia collected from the infected plants were measured for their dimensions, their mean values were 36.120 X 16.620 µm for Acroclinium spp.; 33.921 X 18.220 µm for Cineraria spp.; 29.750 X 15.095 µm for C. officinalis; 28.067 X 14.987 µm for Coreopsis spp.; 31.162 X 15.228 µm for C. sulphureus; 37.852 X 18.300 µm for D. variabilis; 30.675 X 13.811 µm for E. alba; 28.685 X 15.162 µm for H. annuus; 36.012 X 15.010 µm for X. strumarium and 33.910 X 16.126 µm for Z. elegans. The mean length/breadth ratios determined were 2.05, 1.75, 1.90, 2.24, 2.15, 2.05, 2.15, 1.89, 2,14 and 2.32 respectively (Tables 23-32).

Totally , 375 samples were examined for the fibrosin bodies test. Of these, 165 samples showed few conidia without fibrosin bodies, on the other hand conidia of 210 samples had hundred per cent fibrosin bodies (Table 33, Fig. 12). The mean per cent

DISTRICT: ALIGARH

Area - 5025 sq. km

0 25
KM

Localities in the District:

1. Atrauli
2. Charra
3. Sikandra Rao
4. Hathras
5. Mandrak
6. Harduaganj
7. Iglas
8. Khair
9. Tappal

△ Erysiphe cichoracearum

□ Sphaerotheca fuliginea

FIG.3 DISTRIBUTION OF POWDERY MILDEW IN DISTRICT ALIGARH.

occurrence of conidia with fibrosin bodies from these samples was 86.25 and mean number of fibrosin bodies per conidium 7.70 (Table 34, Fig. 13,14). Disc, cone, plate- shaped and well developed fibrosin bodies were invariably present in the conidia of Cineraria spp., C. officinalis and H. annuus. The mean number of fibrosin bodies per conidium in these composites were 5.81, 8.20 and 9.66 with range of 6 to 11 (Table 35, Fig. 15).

After the germination tests, it was observed that simple and forked germ tubes were given out by the conidia. These germ tubes were produced at the side walls and apical end of the conidia. The mean per cent germination was 74.06 and 69.04 for S. fuliginea and E. cichoracearum respectively, while per cent forking in the germ tubes of S. fuliginea was 47.96 (Table 36, Fig. 20,21). On the other hand conidia of E. cichoracearum produced straight germ tubes with well developed appressoria and was lacking fibrosin bodies.

During survey, Chrysanthemum coronarium and Dimorphotheca sinuata were also found with mildew infection in few localities of this district. Moderate disease intensity on C. coronarium was recorded from Sikandra Rao, Hathras and Harduaganj localities, while mild from Atrauli, whereas, D. sinuata was found with mild infection from Charra, Sikandra Rao, Harduaganj and Khair localities of this district. The mean conidial dimension measured were 40.138 X 19.632 µm and 36.210 X 20.332 µm with mean L/B ratio of 2.16 and 1.89 respectively. Conidia isolated from

C. coronarium were found to be longer than those of D. sinuata and were cylindrical in shape. In the conidia of D. sinuata discrete refractive and various shapes of fibrosin bodies were present. The mean number of fibrosin bodies per conidium in this plant observed was 7.15 with range of 7 to 9 (Table 35). On the basis of conidial morphology it can be concluded that C. coronarium was the host for E. cichoracearum, whereas, D. sinuata for S. fuliginea.

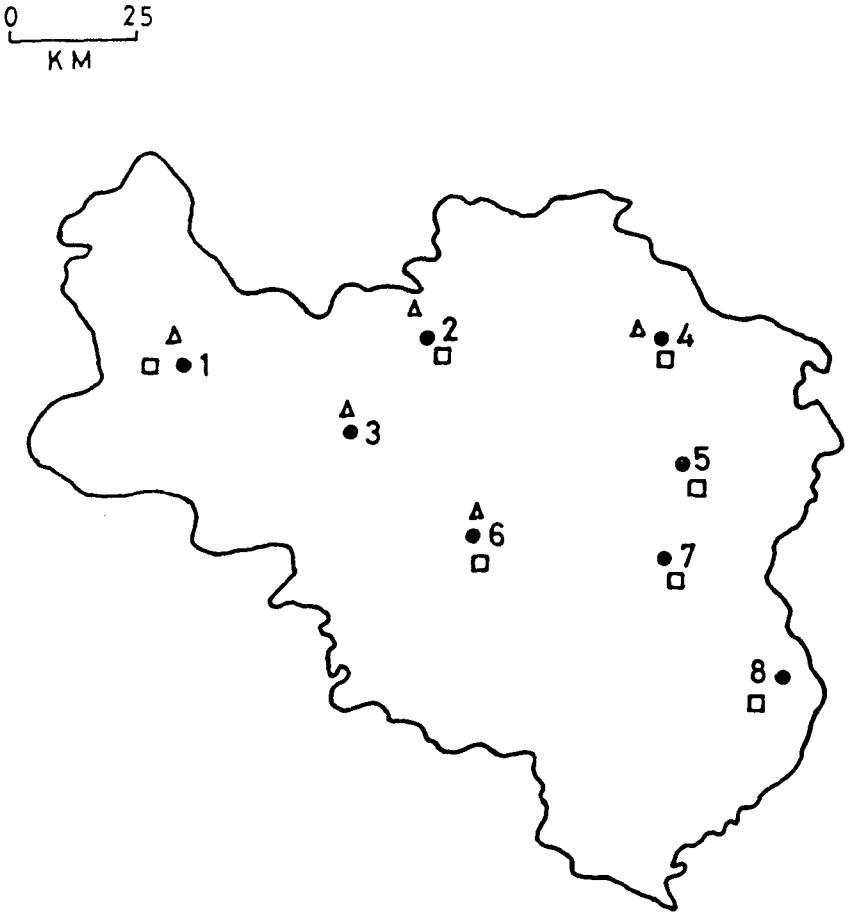
District : Allahabad

The study area which included eight localities of the district showed the cultivation of different composites (Fig. 4, Table 22). The period of survey in this district was last week of March, 1992. The disease intensity on various composites showed a variation among the localities. The plants which were mild or moderately infected in a locality were severely infected in the other. The intensity of the disease was high on D. variabilis among cultivated and on X. strumarium among wild composites (Table 18). The disease incidence was 74 per cent on C. sulphureus and 80 per cent on X. strumarium, while in rest of the plants it remains below 65 per cent (Table 13). The composites encountered during the survey contained anamorph stage of the fungus only.

Tables 23-32 indicate the mean conidial dimensions measured from the collected composites. It is clear that the conidial dimensions varies among Acroclinium spp., Cineraria spp., C. officinalis, Coreopsis spp., C. sulphureus, D. variabilis, E. alba,

DISTRICT: ALLAHABAD

Area - 7255 sq. km



Localities in the District:

1. Manjhanpur
2. Athrampur
3. Chayal
4. Phulpur
5. Handia
6. Karchana
7. Sirma
8. Manda

△ Erysiphe cichoracearum

□ Sphaerotheca fuliginea

FIG. 4 DISTRIBUTION OF POWDERY MILDEW IN DISTRICT ALLAHABAD.

H. annuus, X. strumarium and Z. elegans. The data obtained so were 36.080 X 18.180 µm, 34.158 X 18.805 µm, 28.225 X 15.325 µm, 28.136 X 14.350 µm, 31.080 X 15.125 µm, 36.720 X 17.128 µm, 30.208 X 13.727 µm, 28.438 X 16.316 µm, 35.120 X 13.962 µm and 34.016 X 16.624 µm with mean L/B rations of 2.08, 1.78, 1.97, 2.30, 2.04, 2.10, 2.10, 1.80, 2.16 and 2.18 respectively.

Disc, cone, plate shaped and well developed fibrosin bodies were invariably present in the conidia examined from Cineraria spp., C. officinalis and H. annuus. For the fibrosin bodies test 260 samples were examined, out of these, few conidia of 132 samples possessed fibrosin bodies, while in the remaining 128, all conidia had firbosin bodies (Table 33, Fig. 12). The mean number of conidia with fibrosin bodies observed was 88.68 per cent and number of fibrosin bodies per conidium 8.30 (Table 34, Fig. 13,14). The mean number of fibrosin bodies per conidium in the above mentioned plants were 7.86, 8.89 and 8.15 with range of 5 to 12 (Table 35, Fig. 16).

In the germination tests, it was observed that both types of germ tubes were given out by the conidia. These germ tubes were produced at the side walls and apical portion of the conidia. The mean per cent germination was 69.38 and 72.79 for S. fuliginea and E. cichoracearum respectively. Per cent forking in the germ tubes of S. fuliginea was 48.83 (Table 36, Fig. 20,21). Conidia of E. cichoracearum were devoid of fibrosin bodies and emerge simple germ tubes with appressoria.

District : Bareilly

Survey in different localities of this district was conducted for the occurrence and distribution of powdery mildews on various members of the family Compositae. The period of survey was second week of February, 1992 (Fig. 5). Different cultivated and wild composites were encountered during survey (Table 22). E. alba and X. strumarium were found moderately to severely infected in various localities. In few localities plants were free from the infection. Different plants were invariably found infected with mildew and showed varying degree of disease intensity (Table 18). The incidence of disease was 70 per cent on E. alba and 72 per cent on X. strumarium but below 68 per cent on rest of the plants in different localities (Table 13). Infected samples were having anamorph stage of the pathogen.

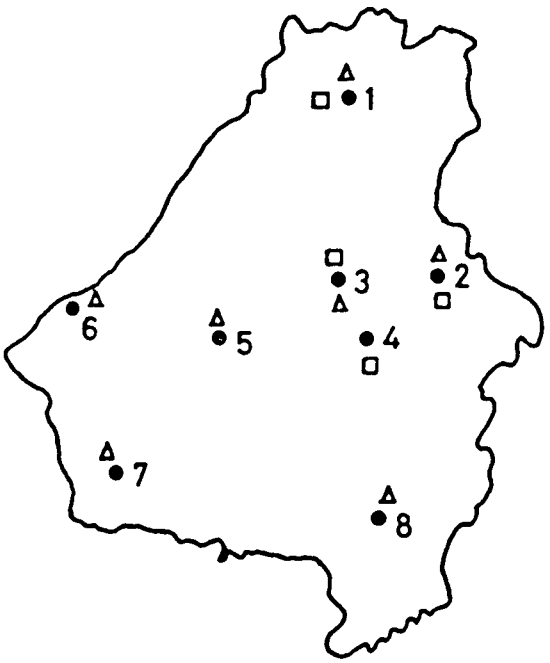
Tables 23-32 shows mean conidial dimensions and mean L/B ratios measured from Acroclinium spp. (36.115 X 18.056 µm; 2.00), Cineraria spp. (35.213 X 18.363 µm; 1.86), C. officinalis (28.665 X 14.986 µm; 1.90), Coreopsis spp. (28.060 X 13.316 µm; 2.12), C. sulphureus (30.708 X 15.085 µm; 2.05), D. variabilis (36.634 X 17.675 µm; 2.05), E. alba (31.130 X 14.533 µm; 2.24), H. annuus (27.216 X 17.012 µm; 1.78), X. strumarium (35.090 X 15.125 µm; 2.10) and Z. elegans (34.002 X 16.823 µm; 2.10).

In all 278 Compositae samples were observed for the fibrosin bodies test. While, observing the fibrosin bodies in conidia it was

DISTRICT: BAREILLY

Area - 4125 sq.km

0 25
KM



Localities in the District:

1. Baheri
2. Nawabganj
3. Bhojipura
4. Rithora
5. W. Fatehganj
6. Sirauli
7. Anwala
8. Makrandpur

△ Erysiphe cichoracearum

□ Sphaerotheca fuliginea

FIG. 5 DISTRIBUTION OF POWDERY MILDEW IN DISTRICT BAREILLY.

noticed that all conidia did not possessed these bodies. Number of samples with few conidia without fibrosin bodies was 150, whereas, all conidia with fibrosin bodies was observed in 128 samples (Table 33, Fig. 12). Mean per cent occurrence of conidia with fibrosin bodies from these samples was 87.08, while mean number of fibrosin bodies per conidium counted 7.78 (Table 34, Fig. 13,14). Well developed, discrete and various shapes of fibrosin bodies were invariably present in the conidia obtained from Cineraria spp., C. officinalis and H. annuus. Mean number of fibrosin bodies per condium in these composites were 8.15, 7.95 and 7.25 and range differs from 5 to 11 (Table 35, Fig. 16).

On germination conidia from different composites produce simple and forked germ tubes. These germ tubes emerge from the side and end portion of the conidia. The mean per cent germination for conidia of S. fuliginea was 74.65, while 77.20 for E. cichoracearum. Per cent forking in the germ tubes of S. fuliginea was 54.77 (Table 36, Fig. 20,21). Conidia of E. cichoracearum produced simple germ tubes (non forked) with well developed appressoria at the tip.

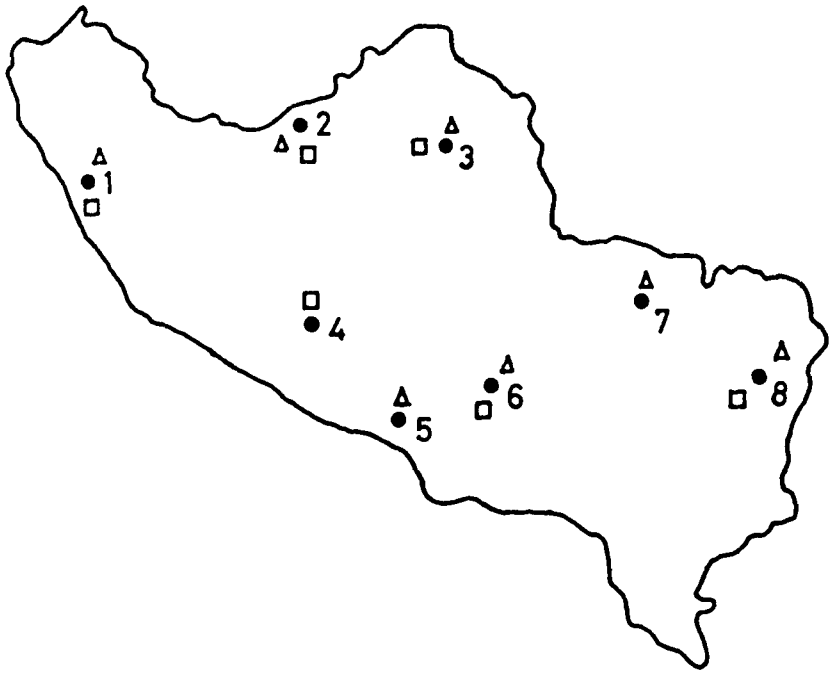
District : Budaun

The study area which included eight localities of the district showed the cultivation of various composites (Table 22, Fig. 6). This district was surveyed for the incidence and intensity of

DISTRICT: BUDAUN

Area - 5158 sq.km

0 25
KM



Localities in the District:

1. Babrala
2. Islamnagar
3. Wazirganj
4. Sahaswan
5. Kachhlaghat
6. Ujhani
7. Binawar
8. Dataganj

△ Erysiphe cichoracearum

□ Sphaerotheca fuliginea

FIG.6 DISTRIBUTION OF POWDERY MILDEW IN DISTRICT BUDAUN.

powdery mildew in the third week of January, 1992. All the infected composites encountered showed a varied degree of disease intensity (Table 19). The severity of the disease on D. variabilis and X. strumarium was high. While Acroclinium spp. and Coreopsis spp. were free from the powdery mildew infection in some localities of this district. The other composites were infected in one or the other locality with varying disease intensity. The incidence of disease was 80 per cent on C. officinalis and D. variabilis; 70 per cent on Cineraria spp. and C. sulphureus; 60 per cent on H. annuus and E. alba. While on the remaining plants it was below 50 per cent (Table 14).

Mean conidial dimensions (length X breadth) measured for Acroclinium spp., Cineraria spp., C. officinalis, Coreopsis spp., C. sulphureus, D. variabilis, E. alba, H. annuus, X. strumarium and Z. elegans were 35.886 X 17.215 µm, 35.108 X 18.625 µm, 28.821 X 15.119 µm, 28.154 X 13.817 µm, 30.660 X 14.060 µm, 37.782 X 18.660 µm, 30.510 X 14.122 µm, 26.012 X 15.018 µm, 35.025 X 15.228 µm and 33.208 X 15.935 µm, while the mean length/breadth ratios for these plants were 2.05, 1.77, 1.80, 2.16, 2.10, 2.08, 2.05, 1.87, 2.20 and 2.05 respectively (Table 23-32).

Well developed, discrete and various shapes of fibrosin bodies were invariably present in the conidia collected from Cineraria spp., C. officinalis and H. annuus (Table 35). For the fibrosin bodies test 247 samples were observed. Out of these few conidia of

146 samples were without fibrosin bodies and in 101 samples these bodies were present in all the conidia observed microscopically (Table 33, Fig. 12). Mean per cent conidia counted with fibrosin bodies were 92.52 while mean number of fibrosin bodies per conidium was 7.38 (Table 34, Fig. 13,14). Mean fibrosin bodies per conidium counted from above mentioned three composites were 7.82, 6.21 and 8.65 with range of 5 to 11 (Table 35, Fig. 17). After studying the germination test it was noted that simple and forked germ tubes were given out by the conidia. The mean per cent germination was 75.08 and 75.59 for S. fuliginea and E. cichoracearum, per cent forking of germ tube of S. fuliginea was 54.79 (Table 36, Fig. 20,21). Conidia of E. cichoracearum produced straight germ tubes with well developed appressoria and it was lacking fibrosin bodies.

Mild to moderate infection on leaves of D. sinuata was observed from Babrala, Kachlaghat, Binawar and Dataganj localities of this district. Conidia were ellipsoidal in shape and arranged in chain. Well developed fibrosin bodies were present in the conidia. The mean number of fibrosin bodies per conidium in this plant noted was 6.86 and range varies from 5 to 10 (Table 35). Mean conidial size measured was 29.758 X 17.326 µm and mean L/B ratio 1.92. These characters were ample to identify the pathogen as S. fuliginea on this Compositae member .

District : Bulandshahr

Various localities in the district were surveyed in the first week of December, 1991 (Fig. 7). Composites encountered are presented in Table-22. Different plants were invariably found with anamorph stage of the fungus and showed varying degree of disease intensity (Table 19). The severity of the disease on H. annuus and X. strumarium was high, while on Cineraria spp., C. sulphureus and D. variabilis was moderate. Mild infection was noted on Acroclinium spp., Coreopsis spp., E. alba and Z. elegans in some localities. The disease incidence was 76 per cent on H. annuus and 80 per cent on X. strumarium. On the remaining composites it was below 50 per cent (Table 14).

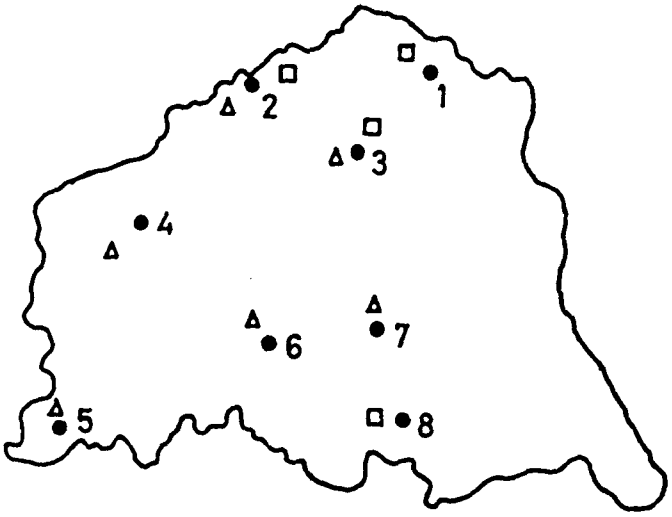
The mean conidial dimensions and L/B ratios were determined of the collected composites. Tables 23-32 shows the mean dimensions of the conidia of various plants, these measurements were 36.109 X 17.576 µm (2.10) for Acroclinium spp., 33.315 X 18.437 µm (1.86) for Cineraria spp., 28.118 X 15.462 µm (1.96) for C. officinalis, 27.775 X 13.210 µm (2.17) for Coreopsis spp., 31.060 X 14.315 µm (2.14) for C. sulphureus, 37.825 X 18.980 µm (2.02) for D. variabilis, 30.718 X 13.910 µm (2.18) for E. alba, 28.462 X 15.512 µm (1.90) for H. annuus, 34.421 X 15.317 µm (2.15) for X. strumarium and 33.715 X 15.746 µm (2.10) for Z. elegans.

Three cultivated composites i.e. Cineraria spp., C. officinalis and H. annuus, were found infected with S. fuliginea pathogen

DISTRICT: BULANDSHAHR

Area - 4895 sq. km

0 25
KM



Localities in the District:

1. Siyana
2. Gulavthi
3. Aurangabad
4. Dankaur
5. Jewar
6. Khurja
7. Shikarpur
8. Pahasu

△ Erysiphe cichoracearum

□ Sphaerotheca fuliginea

FIG.7 DISTRIBUTION OF POWDERY MILDEW IN DISTRICT BULANDSHAHR.

(Table 35). Totally, 159 samples of the collected composites were tested for the presence of fibrosin bodies. Few conidia without fibrosin bodies were observed in 81 samples and in 78 samples hundred per cent fibrosin bodies were present in the conidia (Table 33, Fig. 12). Mean per cent occurrence of conidia with fibrosin bodies was 88.19. Mean number of fibrosin bodies per conidium was counted 7.64 (Table 34, Fig. 13,14). In the conidia of Cineraria spp., C. officinalis, and H. annuus presence of refractive, straight or curved rod like bodies were noted. Mean number of fibrosin bodies per conidium in these composites were 7.15, 8.69 and 7.08 with range of 6 to 10 (Table 35, Fig. 17). The mean per cent germination for S. fuliginea and E. cichoracearum was 79.57 and 82.07. Fibrosin bodies were absent in the conidia of E. cichoracearum and they produced simple germ tubes with well developed appressoria at the tip of germ tube. Forking of the germ tubes of S. fuliginea was 48.11 per cent (Table 36, Fig. 20,21).

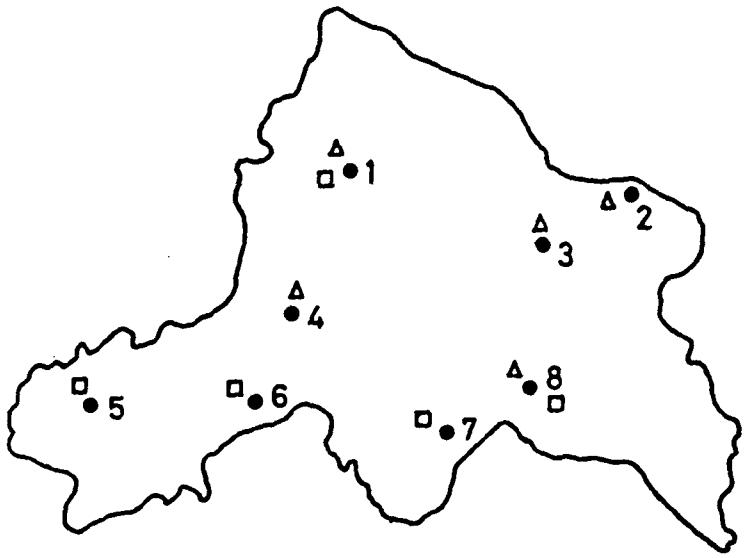
District : Etah

Acroclinium spp., C. officinalis, Cineraria spp., Coreopsis spp., C. sulphureus, D. variabilis, E. alba, H. annuus, X. strumarium and Z. elegans were invariably found infected with powdery mildew in this district when the survey was conducted in the first week of November, 1992 (Fig. 8, Table 22). D. variabilis

DISTRICT: ETAH

Area - 4449 sq. km

0 25
KM



Localities in the District:

1. Kasganj
2. Kadirganj
3. Sahawar
4. Marhara
5. Jalesar
6. Basundhra
7. Malawan
8. Dhumri

△ Erysiphe cichoracearum

□ Sphaerotheca fuliginea

FIG.8 DISTRIBUTION OF POWDERY MILDEW IN DISTRICT ETAH.

and X. strumarium were apparently more heavily infected than those of other composites. But, few plants were found free from the infection at the time of survey. Table-20 clearly indicates the degree of intensity on various plants. The incidence of disease was 70 per cent on C. sulphureus, 77 per cent on X. strumarium and 80 per cent on D. variabilis, but below 60 per cent in the remaining plants (Table 15).

The mean conidial size measured from these plants were 36.323 X 17.215 μm, 34.682 X 18.411 μm, 27.987 X 15.321 μm, 27.992 X 13.763 μm, 31.115 X 15.610 μm, 37.684 X 18.185 μm, 31.056 X 14.700 μm, 29.136 X 16.016 μm, 36.129 X 14.116 μm and 33.525 X 16.621 μm and mean L/B ratios determined were 2.22, 1.83, 1.89, 2.10, 2.03, 2.15, 2.11, 1.81, 2.38 and 2.05 respectively.

S. fuliginea was identified on Cineraria spp., C. officinalis and H. annuus, after the fibrosin bodies test. These bodies were variable in shape like rod, disc, cone, plate and were invariably present in the conidia of the collected samples (Table 35). Out of 307 examined samples of the infected composites, 158 showed few conidia without fibrosin bodies, while in the remaining 149 samples these bodies were invariably present in all the the conidia (Table 33, Fig. 12). The per cent occurrence of conidia with fibrosin bodies was 87.49 and mean number of fibrosin bodies per conidium 9.01, in the observed samples (Table 34, Fig. 13,14). Mean number of fibrosin bodies per conidium in Cineraria spp., C. officinalis

and H. annuus was counted 9.65, 7.55 and 9.83 with range of 5 to 12 (Table 35, Fig. 18). Mean per cent germination for S. fuliginea was 74. 93 and 75.66 for E. cichoracearum. Per cent forking of the germ tubes of S. fuliginea was 52.25 (Table 36, Fig. 20,21). The conidia of E. cichoracearum were devoid of fibrosin bodies and on germination produced simple and straight germ tubes (non forked) with well developed appressoria at the tip of the germ tube.

District : Etawah

Survey for the incidence and intensity was conducted in second week of December, 1992 and again in the fourth week of January, 1993, in various localities of this district (Fig. 9). Table-22 clearly shows the plants encountered during the survey. Varying disease intensity was noted on different composites (Table 20). The severity of the disease on C. sulphureus, D. variabilis, H. annuus and X. strumarium was high. While Acroclinium sp., Cineraria spp., C. officinalis, Coreopsis spp. and Z. elegans were free from the infection in some of the localities. The incidence of the disease was 67 per cent on X. strumarium, 70 per cent E. alba and D. variabilis and 75 per cent on H. annuus. In the remaining plants it remains below 65 per cent (Table 15). Anamorph stage of the fungus was only present on the collected samples.

DISTRICT: ETAWAH

Area - 4327 sq.km

0 25
KM

Localities in the District:

1. Jaswantnagar
2. Chaubiya
3. Bela
4. Bidhuna
5. Bharthana
6. Bakewar
7. Chakarnagar
8. Sarai Ajitmal

△ Erysiphe cichoracearum

□ Sphaerotheca fuliginea

FIG.9 DISTRIBUTION OF POWDERY MILDEW IN DISTRICT ETAWAH.

The mean conidial size measured from Acroclinium spp., Cineraria spp., C. officinalis, Coreopsis spp., C. sulphureus, D. variabilis, E. alba, H. annuus, X. strumarium and Z. elegans were 36.086 X 17.116 µm, 34.428 X 18.132 µm, 29.058 X 15.167 µm, 27.865 X 13.621 µm, 31.085 X 14.120 µm, 37.165 X 18.226 µm, 30.132 X 13.923 µm, 30.319 X 16.219 µm, 36.018 X 14.562 µm, and 34.028 X 16.625 µm respectively and mean L/B ratios were 2.10, 1.90, 1.95, 2.10, 2.18, 2.03, 2.22, 1.88, 2.25 and 2.10.

To study the presence of fibrosin bodies, 209 Compositae samples were examined. Out of these, 112 samples showed few conidia without fibrosin bodies, on the other hand 97 samples showed all conidia with fibrosin bodies (Table 33, Fig. 12). The mean number of conidia with fibrosin bodies was 87.15 per cent and the mean number of fibrosin bodies per conidium 8.45 (Table 34, Fig. 13,14). Well developed, discrete and various shapes of fibrosin bodies were invariably present in the conidia of powdery mildew collected from Cineraria spp, C. officinalis and H. annuus. The mean number of fibrosin bodies per conidium in these plants were 9.89, 7.27 and 8.19, while range varies from 5 to 12 (Table 35, Fig. 18). The mean per cent germination of S. fuliginea and E. cichoracearum was 76.75 and 79.21 respectively. Per cent forking in the germ tube of S. fuliginea was 51.38 (Table 36, Fig. 20,21). Conidia of E. cichoracearum produced straight germ tubes

with well developed appressoria. The germ tubes emerge from the basal/apical portion of the conidia.

Severely infected plants of C. coronarium were observed from Bela, Bidhuna and Chakarnagar, while mild infection from Jaswantnagar and Bakewar localities of this district. Mycelium was well developed and ectophytic in nature. Conidia were cylindrical in shape and devoid of fibrosin bodies. The mean conidial dimension measured 28.280 X 13.532 µm and mean length/breadth determined was 2.06. On these characteristics E. cichoracearum was recognized as the causal agent of disease on this plant.

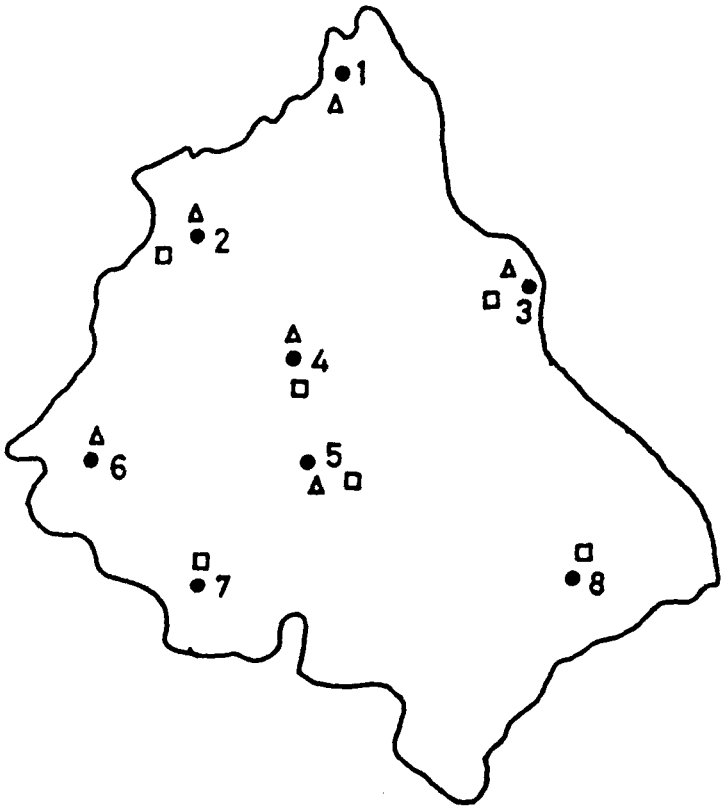
District : Kanpur

The study area which included various localities of the district are presented in Fig. 10. Different Compositae members were encountered with powdery mildew infection and invariably showed varying degree of disease intensity (Table 21). This district was surveyed in the first week of October, 1992. The severity of the disease on C. officinalis, C. sulphureus and X. strumarium was high in some localities, while others were mild to moderately infected. It was observed that in few localities plants were free from the infection. The disease incidence was 70 per cent on Cineraria spp., D. variabilis, and X. strumarium; 65 per cent on C. sulphureus but below 60 per cent on the remaining plants

DISTRICT: KANPUR

Area - 6121 sq.km

0 25
KM



Localities in the District:

1. Makanpur
2. Rasulabad
3. Bithur
4. Rura
5. Akbarpur
6. Sikandra
7. Bhognipur
8. Sadh

▲ Erysiphe cichoracearum

□ Sphaerotheca fuliginea

FIG.10 DISTRIBUTION OF POWDERY MILDEW IN DISTRICT KANPUR.

(Table 16). All the collected samples were found with anamorph stage of the fungus. Tables 23-32 clearly shows the mean conidial dimensions of Acroclinium spp. (36.989 X 17.850 μm), Cineraria spp. (34.402 X 18.063 μm), C. officinalis (29.765 X 15.227 μm), Coreopsis spp. (28.115 X 13.775 μm), C. sulphureus (31.162 X 15.050 μm), D. variabilis (37.467 X 18.159 μm), E. alba (31.060 X 14.805 μm), H. annuus (30.016 X 16.312 μm), X. strumarium (35.332 X 15.395 μm) and Z. elegans (33.662 X 15.327 μm) and the mean length/breadth ratios determined were 2.12, 1.89, 1.85, 2.10, 2.10, 2.05, 2.13, 1.90, 2.24 and 2.21.

For the fibrosin bodies test 263 samples were observed and it was found that out of these, 183 samples contain few conidia without fibrosin bodies but in the remaining 80 samples these bodies were present in all the conidia (Table 33, Fig. 12). The mean per cent occurrence of conidia with fibrosin bodies was 89.64 and mean number of fibrosin bodies per conidium counted was 7.74 (Table 34, Fig. 13,14). Cineraria spp., C. officinalis and H. annuus were found infected with S. fuliginea from this district. The conidia of these plants possessed well developed fibrosin bodies. The mean number of fibrosin bodies per conidium in these plants counted were 7.33, 8.32 and 7.58, whereas, range varies form 5 to 11 (Table 35, Fig. 19).

While observing the germination tests it was noticed that simple and forked germ tubes emerge from the conidia. Mean per

cent germination for S. fuliginea and E. cichoracearum was 76.85 and 75.43 respectively. Per cent forking in the germ tubes of S. fuliginea was 53.14 (Table 36, Fig. 20,21). The conidia of E. cichoracearum were devoid of fibrosin bodies and produced simple germ tubes with appressorial development at the tip of the germ tubes.

Moderate to mild infection on leaves of C. coronarium was observed from Rasulabad, Rura, Akbarpur and Sikandra localities of this district. While observing the morphology of conidia it was found cylindrical and barrel shaped and devoid of fibrosin bodies. The mean conidial dimension measured was 28.520 X 13.082 µm and mean L/B ratio 2.15. Due to the absence of fibrosin bodies in the conidia the pathogen was indentified as E. cichoracearum.

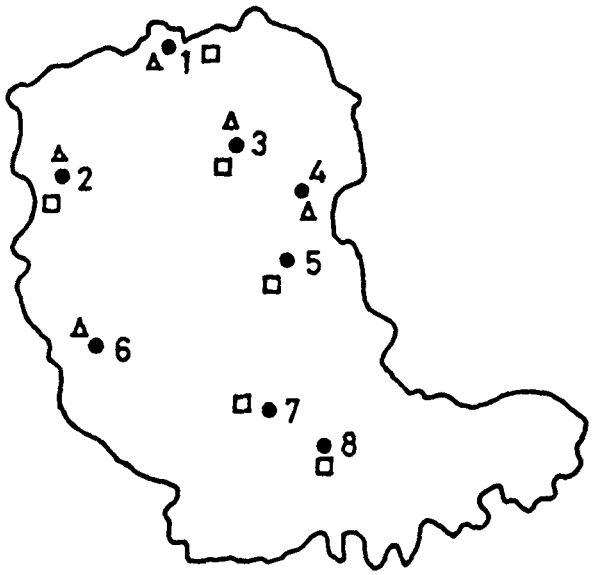
District : Mathura

For the incidence and intensity of powdery mildew on various composites, some localities in this district in the fourth week of February, 1992 were surveyed (Fig. 11, Table 22). The disease intensity was high on C. officinalis, C. sulphureus and D. variabilis among cultivated and on E. alba among wild composites (Table 21). The disease incidence was 62 per cent on C. officinalis, 68 per cent on D. variabilis and 70 per cent on E. alba, while on rest of the plants it was below 60 per cent (Table 16). For determining the mean conidial size from various

DISTRICT: MATHURA

Area- 3797 sq.km

0 25
KM



Localities in the District:

1. Shahpur
2. Barsana
3. Chhata
4. Akbarpur
5. Brindaban
6. Govardhan
7. Gokul
8. Baldev

▲ Erysiphe cichoracearum

□ Sphaerotheca fuliginea

FIG. 11 DISTRIBUTION OF POWDERY MILDEW IN DISTRICT MATHURA.

plants the length and breadth of conidia were measured and L/B ratio was determined. The data presented in Tables 23-32 clearly shows the mean conidial size of Acroclinium spp. (35.895 X 16.362 µm; ratio 2.15), Cineraria spp. (33.608 X 18.214 µm; ratio 1.84), C. officinalis (29.162 X 14.863 µm; ratio 1.93), Coreopsis spp. (27.910 X 13.229 µm; ratio 2.13), C. sulphureus (30.925 X 14.928 µm; ratio 2.07), D. variabilis (37.645 X 18.089 µm; ratio 2.13), E. alba (30.105 X 14.128 µm; ratio 2.15), H. annuus (28.525 X 16.082 µm; ratio 1.84), X. strumarium (35.024 X 15.178 µm; ratio 2.28), and Z. elegans (32.247 X 15.860 µm; ratio 2.10).

For the fibrosin bodies test, 412 samples were examined, out of these 254 contain few conidia without fibrosin bodies, while in rest of the 158 samples these bodies were present in all the conidia (Table 33, Fig. 12). The mean per cent occurrence of conidia with fibrosin bodies from these samples was 89.28 and mean number of fibrosin bodies per conidium was 8.11 (Table 34, Fig. 13,14). Well developed, refractive with various shapes of fibrosin bodies were invariably present in the conidia of powdery mildew collected from Cineraria spp., C. officinalis, and H. annuus from this district. So, the presence of S. fuliginea on these plants could not be ruled out. The mean number of fibrosin bodies per conidium counted from these plants were 6.85, 8.60, and 8.90 with range of 5 to 12 (Table 35, Fig. 19).

While observing the germination tests it was noted that both type of germ tubes were given out by the conidia. The mean per cent germination was 73.33 for S. fuliginea and 83.39 for E. cichoracearum pathogen. Per cent forking in S. fuliginea germ tubes was 52.46. The conidia of E. cichoracearum on germination produced simple and straight germ tubes with well developed appressoria at the tip (Table 36, Fig. 20,21).

Beside above mentioned plants, C. coronarium was also found with powdery mildew infection in few localities (Shahpur, Barsana and Govardhan) of this district. Mild to moderate infection was noted on the plants in these localities. Conidial stage of the fungus was present, characteristic of E. cichoracearum as conidia were cylindrical and barrel shaped and lacking fibrosin bodies. On measuring the mean size of the conidia was found to be 29.263 X 13.864 µm with mean L/B ratio of 2.13.

Overall assessment

The areas included in the study in the districts of Agra, Aligarh, Allahabad, Bareilly, Budaun, Bulandshahr, Etah, Etawah, Kanpur and Mathura, various Compositae members were found to be infected with two powdery mildews viz. E. cichoracearum and S. fuliginea, though E. cichoracearum is predominant and mainly responsible for the disease on the members of this family. The identity was determined mainly on the characters of anamorph of

the species. Conidial measurements, fibrosin bodies and germination tests results supplement the identity determinants.

Acroclinium spp., Coreopsis spp., C. sulphureus, D. variabilis, E. alba, X. strumarium and Z. elegans were found infected with E. cichoracearum, while Cineraria spp., C. officinalis and H. annuus were found with S. fuliginea from all the surveyed districts. Beside these plants, C. coronarium and D. sinuata were also found infected with powdery mildew in few districts. C. coronarium was found infected with E. cichoracearum from the districts of Agra, Aligarh, Etawah, Kanpur and Mathura, whereas, D. sinuata was found with S. fuliginea from the districts of Aligarh and Budaun. In overall assessment, E. cichoracearum was mainly responsible for the disease in these districts.

Consistency in anamorph characters

Anamorph characters such as ectophytic nature of mycelium, morphology of conidiophores in relation to branching, arrangement of conidia on conidiophores, shape of conidia, dimensions of conidia, length/breadth ratio, presence or absence of fibrosin bodies in conidia, morphology and point of emergence of germ tubes on conidia and development of appressoria were examined for their consistency in the samples of composites with powdery mildew collected from various districts in Uttar Pradesh. The main

objective of these studies was to determine the reliability of these characters for utilizing them in identification of powdery mildew species infecting composites. The observations made for each characteristics are as follows :

Mycelium

In general, mycelium was ectophytic irrespective of the locality or district or the infected composite involved. This character was common in all the samples examined and identified as E. cichoracearum and S. fuliginea. In L. taurica, which also infects composites, mycelium is endophytic. So, on the basis of ectophytic nature of mycelium the possiblity of L. taurica causing powdery mildew of composites, in these studies can be eliminated.

Conidiophores

Conidiophores in all the samples of composites infected with powdery mildew were invariably unbranched and septate. This character was also common in the examined samples and identified as E. cichoracearum and S. fuliginea.

Conidia

Conidia were borne in chain in basipetal succession on conidiophores and this character was also common to both the pathogens. The possibility of involvement of L. taurica was

eliminated, where conidiophores are branched emerging through stomata, bearing conidia singly at the tips of conidiophore branches.

Shape and Size of Conidia

Shape and size of conidia studied in all the samples of infected composites showed consistency and were of taxonomic importance. Shape of conidia in different collections from various districts showed a great deal of consistency. Two types of conidia were identified from the collected samples. Conidia of S. fuliginea were ellipsoidal in shape, while those of E. cichoracearum were barrel shaped with a tendency towards cylindrical shape. Thus the shape of conidia of these two powdery mildew species varied and were consistent regardless of composite sample or locality or district. The data on measurements of length and breadth of conidia from all the samples of various districts are presented in Tables 23-32. Some variations, were observed in conidial dimensions when considered composite-wise or district-wise (Tables 23-32). Length/breadth (L/B) ratio calculated from the measurements of length and breadth of all conidia of each composite showed more or less consistent figure. It was more than 2 (mostly 2.10) for E. cichoracearum and was less than 2 (mostly 1.80) for S. fuliginea (Tables 23-32). The measurement of conidia in relation to length, breadth and L/B ratio appeared to be greatly consistent and

was useful for differentiating E. cichoracearum from S. fuliginea.

Fibrosin bodies

The data presented in Table-34 and 35 shows that fibrosin bodies were invariably present in the conidia of powdery mildew. Fibrosin bodies were well developed, discrete and easily distinguishable. These were, however not present in all the conidia of all the samples of composites (Fig. 12). A number of conidia in some of the samples were devoid of fibrosin bodies, of all the 2917 samples collected from different districts examined, 1485 showed some conidia without fibrosin bodies whereas, in 1432 samples, fibrosin bodies were invariably present in all the conidia.

The per cent occurrence of fibrosin bodies in conidia ranged from 86.25 to 92.52. Number of fibrosin bodies per conidium also varied. Mean number of fibrosin bodies per conidium in various districts ranged between 7.38 to 9.01. The presence of fibrosin bodies in the conidia, showed that this character is of great taxonomic value and is useful and reliable for identification of S. fuliginea and E. cichoracearum infecting composites.

Germination of Conidia

The data on conidial germination, forking of germ tubes and appressorial development are presented in Table-36. The per cent germination of conidia varied in the samples of composites collected

Table 12

Frequency of Occurrence of powdery mildews on Compositae in some localities of Agra and Aligarh district

Localities	Frequency of Occurrence (%)									
	Acr	Cin	Co	Cor	Cs	Dv	Ea	Ha	Xa	Ze
Agra										
1. Jagner	70	30	45	15	73	70	60	30	70	30
2. Sarendhi	60	0	30	0	45	30	0	10	30	40
3. Fatehpursikri	0	0	35	0	56	-	15	25	40	0
4. Runakata	30	0	-	-	0	10	0	25	50	0
5. Khandauli	0	20	-	10	-	25	19	10	15	0
6. Tundla	35	20	45	-	44	50	26	15	10	15
7. Iradatnagar	40	25	-	0	33	-	32	0	40	10
8. Fatehabad	-	0	35	-	-	35	55	22	46	25
9. Jetpur	60	0	-	-	40	10	-	0	35	40
Aligarh										
1. Atrauli	50	-	50	25	55	0	25	0	45	0
2. Charra	-	35	45	0	-	25	49	0	50	40
3. Sikandra Rao	70	-	30	0	50	30	0	45	40	0
4. Hathras	50	0	-	0	30	36	50	30	36	0
5. Mandrak	-	-	25	15	50	45	40	35	25	20
6. Harduaganj	45	35	25	-	50	50	45	0	10	10
7. Iglas	30	0	10	0	70	70	45	45	10	10
8. Khair	0	-	0	-	0	70	0	30	30	25
9. Tappal	50	-	10	-	0	30	0	0	25	0

0 = No infection; - = Plant not found; Acr = Acroclinium sp.; Cin = Cineraria sp.; Co = Calendula officinalis; Cor = Coreopsis sp.; Cs = Cosmos sulphureus; Dv = Dahlia variabilis; Ea = Eclipta alba; Ha = Helianthus annuus; Xs = Xanthium strumarium; Ze = Zinnia elegans

Table 13

Frequency of Occurrence of powdery mildews on Compositae in some localities of Allahabad and Bareilly district

Localities	Frequency of Occurrence (%)									
	Acr	Cin	Co	Cor	Cs	Dv	Ea	Ha	Xa	Ze
Allahabad										
1. Manjhanpur	50	35	10	15	74	60	55	0	10	15
2. Athrampur	30	42	20	0	46	55	0	15	30	0
3. Chayal	45	0	25	0	50	33	0	0	45	0
4. Phulpur	0	0	20	0	60	0	25	0	80	0
5. Handia	-	0	0	0	35	25	15	30	65	15
6. Karchana	0	15	28	-	33	10	25	20	35	35
7. Sisma	15	-	31	-	42	15	40	0	0	0
8. Manda	0	10	46	0	0	0	45	-	45	0
Bareilly										
1. Baheri	35	10	50	0	50	0	50	0	56	-
2. Nawabganj	28	0	-	-	40	45	70	10	0	-
3. Bhojipura	18	0	15	30	30	30	0	15	68	30
4. Rithora	30	0	15	40	20	35	60	30	0	0
5. W. Fatehganj	0	-	32	-	28	-	30	0	72	-
6. Sirauli	-	40	30	0	35	30	0	-	0	0
7. Anwala	0	28	0	-	0	0	30	0	15	15
8. Makrandpur	40	0	-	-	40	-	35	35	25	30

0 = No infection; - = Plant not found; Acr = Acroclinium sp.; Cin = Cineraria sp.; Co = Calendula officinalis; Cor = Coreopsis sp.; Cs = Cosmos sulphureus; Dv = Dahlia variabilis; Ea = Eclipta alba; Ha = Helianthus annuus; Xs = Xanthium strumarium; Ze = Zinnia elegans

Table 14

Frequency of Occurrence of powdery mildews on Compositae in some localities of Budaun and Bulandshahr district

Localities	Frequency of Occurrence (%)									
	Acr	Cin	Co	Cor	Cs	Dv	Ea	Ha	Xs	Ze
Budaun										
1. Babrala	40	70	30	22	10	0	10	46	50	28
2. Islamnagar	35	46	50	36	20	46	20	50	0	0
3. Wazirganj	0	-	48	0	70	80	30	40	35	0
4. Sahaswan	0	50	50	0	36	45	40	60	33	50
5. Kachhlaghat	0	-	50	0	50	10	45	10	20	-
6. Ujhani	40	0	80	-	-	0	-	60	10	0
7. Binawar	50	0	40	35	40	40	33	0	0	36
8. Dataganj	-	-	0	-	35	50	60	0	18	-
Bulandshahr										
1. Siyana	40	0	10	0	35	0	0	0	42	25
2. Gulavthi	0	0	0	10	40	30	36	30	38	-
3. Aurangabad	-	0	30	20	-	35	48	38	80	36
4. Dankaur	30	40	40	0	40	40	50	76	50	-
5. Jewar	20	10	20	-	10	10	40	50	40	50
6. Khurja	25	30	-	-	20	50	30	42	30	0
7. Shikarpur	-	0	25	0	-	40	0	50	30	-
8. Pahasu	-	-	10	35	30	0	20	44	35	37

0 = No infection; - = Plant not found; Acr = Acroclinium sp.; Cin = Cineraria sp.; Co = Calendula officinalis; Cor = Coreopsis sp.; Cs = Cosmos sulphureus; Dv = Dahlia variabilis; Ea = Eclipta alba; Ha = Helianthus annuus; Xs = Xanthium strumarium; Ze = Zinnia elegans

Table 15

Frequency of Occurrence of powdery mildews on Compositae in some localities of Etah and Etawah district

Localities	Frequency of Occurrence (%)									
	Acr	Cin	Co	Cor	Cs	Dv	Ea	Ha	Xs	Ze
Etah										
1. Kasganj	50	0	60	0	70	0	30	40	0	0
2. Kadirganj	0	0	42	0	50	60	50	50	77	0
3. Sahawar	0	15	0	0	30	55	40	16	55	40
4. Marhara	40	20	33	55	0	40	0	0	46	30
5. Jalesar	0	10	0	0	40	30	35	0	30	50
6. Basundhra	-	36	0	0	50	80	60	48	0	0
7. Malawan	45	-	40	60	0	58	0	50	29	-
8. Dhumri	0	0	45	0	35	35	55	60	43	51
Etawah										
1. Jaswantnagar	0	60	0	45	55	40	45	44	58	0
2. Chaubiya	-	48	35	10	40	50	70	75	60	0
3. Bela	30	0	40	25	-	62	55	0	10	-
4. Bidhuna	50	0	0	0	60	70	65	30	20	53
5. Bharthana	45	55	30	0	50	0	30	45	67	50
6. Bakewar	0	0	10	-	35	10	40	50	56	-
7. Chakarnagar	0	0	0	0	39	20	55	60	44	44
8. Sarai Ajitmal	60	43	0	38	42	30	20	30	0	43

0 = No infection; - = Plant not found; Acr = *Acroclinium* sp.; Cin = *Cineraria* sp.; Co = *Calendula officinalis*; Cor = *Coreopsis* sp.; Cs = *Cosmos sulphureus*; Dv = *Dahlia variabilis*; Ea = *Eclipta alba*; Ha = *Helianthus annuus*; Xs = *Xanthium strumarium*; Ze = *Zinnia elegans*

Table 16

Frequency of Occurrence of powdery mildews on Compositae in some localities of Kanpur and Mathura district

Localities	Frequency of Occurrence (%)									
	Acr	Cin	Co	Cor	Cs	Dv	Ea	Ha	Xs	Ze
Kanpur										
1. Makanpur	0	50	35	0	50	60	60	0	10	0
2. Rasulabad	0	0	60	0	40	56	50	0	60	0
3. Bithur	0	46	0	30	0	55	0	55	50	30
4. Rura	50	0	46	10	60	0	10	40	40	25
5. Akbarpur	0	0	0	15	65	54	40	0	70	20
6. Sikandra	40	45	50	28	38	0	45	30	25	10
7. Bhognipur	-	75	54	0	20	70	0	38	10	28
8. Sadh	0	-	30	35	10	28	10	40	15	15
Mathura										
1. Shahpur	0	-	32	40	15	48	20	0	40	40
2. Barsana	-	55	42	48	0	20	30	30	20	0
3. Chhata	45	40	60	-	30	68	0	0	15	0
4. Akbarpur	-	30	0	-	45	50	46	0	0	50
5. Brindaban	50	0	25	60	40	33	35	35	30	40
6. Govardhan	0	0	0	50	20	48	70	0	0	30
7. Gokul	0	25	0	40	0	29	20	40	50	0
8. Baldev	33	-	62	-	20	41	70	45	20	25

0 = No infection; - = Plant not found; Acr = Acroclinium sp.; Cin = Cineraria sp.; Co = Calendula officinalis; Cor = Coreopsis sp.; Cs = Cosmos sulphureus; Dv = Dahlia variabilis; Ea = Eclipta alba; Ha = Helianthus annuus; Xs = Xanthium strumarium; Ze = Zinnia elegans

Table 17

Severity of powdery mildew on Compositae in some localities of Agra and Aligarh district

Localities	Composites Infected									
	Acr	Cin	Co	Cor	Cs	Dv	Ea	Ha	Xs	Ze
Agra										
1. Jagner	+	+	++	+	+++	+++	++	+++	++	+
2. Sarendhi	+	-	+	-	+++	+++	-	++	+++	++
3. Fatehpursikri	-	-	++	-	+++		++	+++	+++	-
4. Runakata	+	-			-	++	-	+++	+++	-
5. Khandauli	-	+		+		++	++	+	+	-
6. Tundla	++	++	+++		+++	+++	++	++	++	+
7. Iradatnagar	+	+		-	+++		++	-	+++	+
8. Fatehabad		-	++			+++	+	+++	+++	++
9. Jetpur	+	-			+++	++		-	+++	+
Aligarh										
1. Atrauli	+		+++	+	+++	-	+	-	++	-
2. Charra		+	++	-		+	++	-	+	+
3. Sikandra Rao	++		+	-	+++	+++	-	++	+	-
4. Hathras	++	-		-	+	++	+	++	++	-
5. Mandrak			+	+	+++	+++	+	+++	+++	++
6. Harduaganj	++	+	+++		+++	+++	+	-	++	++
7. Iglas	+	-	+++	-	+	+++	++	+	+++	+
8. Khair	-		-		-	+	-	+	+	+
9. Tappal	+		+		-	+++	-	-	++	-

\- = No infection; + = Mild; ++ = Moderate; +++ = Severe infection

Acr = *Acroclinium* sp.; Cin = *Cineraria* sp.; Co = *Calendula officinalis*; Cor = *Coreopsis* sp.; Cs = *Cosmos sulphureus*; Dv = *Dahlia variabilis*; Ea = *Eclipta alba*; Ha = *Helianthus annuus*; Xs = *Xanthium strumarium*; Ze = *Zinnia elegans*.

Table 18

Severity of powdery mildew on Compositae in some localities of Allahabad and Bareilly district

Localities	Composites Infected									
	Acr	Cin	Co	Cor	Cs	Dv	Ea	Ha	Xs	Ze
Allahabad										
1. Manjhanpur	+	++	++	+	+	+++	+	-	+++	+
2. Athrampur	+	+	+	-	++	+	-	+	+++	-
3. Chayal	++	-	+	-	++	+++	-	-	+++	-
4. Phulpur	-	-	+	-	++	-	++	-	++	-
5. Handia		-	-	-	+	+++	++	++	+++	+
6. Karchana	-	+	++		+++	++	+	+	+++	++
7. Sirma	+		++		+	++	+	-	-	-
8. Manda	-	++	+	-	-	-	+		+++	-
Bareilly										
1. Baheri	++	+	+	-	+++	-	++	-	++	
2. Nawabganj	+	-			+	++	+++	+	-	
3. Bhojipura	+	-	+	+	++	+++	-	+	++	+
4. Rithora	++	-	+	+	+	++	++	+	-	-
5. W. Fatehganj	-		+		+		+++	-	+++	
6. Sirauli		+	++	-	+	++	-		-	-
7. Anwala	-	++	-		-	-	+++	-	++	+
8. Makrandpur	++	-			++		++	++	+++	++

\- = No infection; + = Mild; ++ = Moderate; +++ = Severe infection

Acr = *Acroclinium* sp.; Cin = *Cineraria* sp.; Co = *Calendula officinalis*; Cor = *Coreopsis* sp.; Cs = *Cosmos sulphureus*; Dv = *Dahlia variabilis*; Ea = *Eclipta alba*; Ha = *Helianthus annuus*; Xs = *Xanthium strumarium*; Ze = *Zinnia elegans*.

Table 19

Severity of powdery mildew on Compositae in some localities of Budaun and Bulandshahr district

Localities	Composites Infected									
	Acr	Cin	Co	Cor	Cs	Dv	Ea	Ha	Xs	Ze
Budaun										
1. Babrala	+	+	+	+	++	–	+	+	++	+
2. Islamnagar	++	+	+	+	+	++	+	+	–	–
3. Wazirganj	–		+	–	+	+++	+	++	+++	–
4. Sahaswan	–	+	++	–	+	+++	++	+	+++	++
5. Kachhlaghat	–		+	–	++	++	+	+	+++	
6. Ujhani	+	–	+			–		++	++	–
7. Binawar	++	–	+	+	++	+++	+	–	–	+
8. Dataganj			–		+	+++	++	–	++	
Bulandshahr										
1. Siyana	+	–	+	–	++	–	–	–	++	+
2. Gulavthi	–	–	–	+	++	++	+	+++	+	
3. Aurangabad		–	++	+		+	++	+	++	+
4. Dankaur	+	++	++	–	++	++	+	++	++	
5. Jewar	+	++	+		+	+	+	+	++	+
6. Khurja	++	+			+	++	+	+++	+++	–
7. Shikarpur		–	++	–		+	–	+	+++	
8. Pahasu			++	+	++	–	++	++	+	++

– = No infection; + = Mild; ++ = Moderate; +++ = Severe infection

Acr = Acroclinium sp.; Cin = Cineraria sp.; Co = Calendula officinalis; Cor = Coreopsis sp.; Cs = Cosmos sulphureus; Dv = Dahlia variabilis; Ea = Eclipta alba; Ha = Helianthus annuus; Xs = Xanthium strumarium; Ze = Zinnia elegans.

Table 20

Severity of powdery mildew on Compositae in some localities of Etah and Etawah district

Localities	Composites Infected									
	Acr	Cin	Co	Cor	Cs	Dv	Ea	Ha	Xs	Ze
Etah										
1. Kasganj	+	–	++	–	++	–	+	++	–	–
2. Kadirganj	–	–	+	–	++	++	+	++	++	–
3. Sahawar	–	+	–	–	+	++	++	+	+++	+
4. Marhara	+	+	+	+	–	+++	–	–	+	++
5. Jalesar	–	++	–	–	++	++	++	–	+++	++
6. Basundhra		+	–	–	+	++	+	++	–	–
7. Malawan	+		+	+	–	+++	–	+	+++	
8. Dhumri	–	–	++	–	+++	+	+	++	+++	++
Etawah										
1. Jaswantnagar	–	+	–	+	+++	+++	++	+++	+++	–
2. Chaubiya		+	++	+	+	+	+	+++	+	–
3. Bela	+	–	+	+		++	+	–	+++	
4. Bidhuna	++	–	–	–	+++	+++	+	+	++	+
5. Bharthana	+	+	+	–	+++	–	++	+++	+++	++
6. Bakewar	–	–	+		++	+++	+	+++	+++	
7. Chakarnagar	–	–	–	–	+++	+++	+	+	+++	+
8. Sarai Ajitmal	+	+	–	+	++	+	+	+++	–	++

– = No infection; + = Mild; ++ = Moderate; +++ = Severe infection

Acr = Acroclinium sp.; Cin = Cineraria sp.; Co = Calendula officinalis; Cor = Coreopsis sp.; Cs = Cosmos sulphureus; Dv = Dahlia variabilis; Ea = Eclipta alba; Ha = Helianthus annuus; Xs = Xanthium strumarium; Ze = Zinnia elegans.

Table 21

Severity of powdery mildew on Compositae in some localities of Kanpur and Mathura district

Localities	Composites Infected									
	Acr	Cin	Co	Cor	Cs	Dv	Ea	Ha	Xs	Ze
Kanpur										
1. Makanpur	-	+	+++	-	+	+	+	-	+	-
2. Rasulabad	-	-	+++	-	+++	+	+	-	+	-
3. Bithur	-	+	-	+	-	++	-	+	+	++
4. Rura	+	-	+++	++	++	-	+	++	+++	+
5. Akbarpur	-	-	-	+	+++	++	++	-	+++	+
6. Sikandra	+	+	+++	++	++	-	+	+	++	+
7. Bhognipur		++	+++	-	+++	++	-	++	+++	++
8. Sadh	-		++	+	+++	+	+	+	++	+
Mathura										
1. Shahpur	-		+++	+	++	+++	+++	-	++	+
2. Barsana		+	+	++	-	+	+++	+	++	-
3. Chhata	+	+	+++		+++	++	-	-	+	-
4. Akbarpur		++	-		++	+++	++	-	-	+
5. Brindaban	+	-	+++	+	+	++	+	++	++	++
6. Govardhan	-	-	-	++	++	+	+++	-	-	++
7. Gokul	-	++	-	++	-	+++	+++	+	++	-
8. Baldev	+		++		+++	++	+++	++	+	++

\- = No infection; + = Mild; ++ = Moderate; +++ = Severe infection

Acr = *Acroclinium* sp.; Cin = *Cineraria* sp.; Co = *Calendula officinalis*;

Cor = *Coreopsis* sp.; Cs = *Cosmos sulphureus*; Dv = *Dahlia variabilis*;

Ea = *Eclipta alba*; Ha = *Helianthus annuus*; Xs = *Xanthium strumarium*;

Ze = *Zinnia elegans*.

Table 22

Different plants of the family Compositae found infected with powdery mildew in some distrcts of Uttar Pradesh

District	Period of Survey	Members of Compositae found
Agra	First week of November, 1991	Acroclinium sp., Calendula officinalis, Cosmos sulphureus, Chrysanthemum coronarium, Cineraria sp., Coreopsis sp Dahlia variabilis, Eclipta alba, Helianthus annuus, Xanthium strumarium, Zinnia elegans.
Aligarh	Last week of October, 1991 & First week of December, 1992	Acroclinium sp., C. officinalis, C. sulphureus, C. coronarium, Cineraria sp., Coreopsis sp., D. variabilis, Dimorphotheca sinuata, E. alba, H. annuus, X. strumarium, Z. elegans.
Allahabad	Last week of March, 1992	Acroclinium sp., C. officinalis, Cineraria sp., Coreopsis sp., C. sulphureus, D. variabilis, E. alba, H. annuus, X. strumarium, Z. elegans.
Bareilly	Second week of February, 1992	Acroclinium sp., C. officinalis, Cineraria sp., Coreopsis sp., C. sulphureus, D. variabilis, E. alba, H. annuus, X. strumarium, Z. elegans.
Budaun	Third week of January, 1992	Acroclinium sp., C. officinalis, C. sulphureus, Cineraria sp., Coreopsis sp., D. variabilis, D. sinuata, E. alba, H. annuus, X. strumarium, Z. elegans.

Contd.

Table 22 (Contd.)

Bulandshahr	First week of December, 1991	Acroclinium sp., C. officinalis, Cineraria sp., Coreopsis sp., C. sulphureus, D. variabilis, E. alba, H. annuus, X. strumarium, Z. elegans.
Etah	First week of November, 1992	Acroclinium sp., C. officinalis, Cineraria sp., Coreopsis sp., C. sulphureus, D. variabilis, E. alba, H. annuus, X. strumarium, Z. elegans.
Etawah	Second week of December, 1992 & Fourth week of January, 1993	Acroclinium sp., C. officinalis, Cineraria sp., C. coronarium, Coreopsis sp., C. sulphureus, D. variabilis, E. alba, H. annuus, X. strumarium, Z. elegans.
Kanpur	First week of October, 1992	Acroclinium sp., C. officinalis, Cineraria sp., Coreopsis sp., C. coronarium, C. sulphureus, D. variabilis, E. alba, H. annuus, X. strumarium, Z. elegans.
Mathura	Fourth week of February, 1992	Acroclinium sp., C. officinalis, Cineraria sp., Coreopsis sp., C. coronarium, C. sulphureus, D. variabilis, E. alba, H. annuus, X. strumarium, Z. elegans.

Table 23

Dimensions* of powdery mildew conidia of Acroclinium spp. from various districts of Uttar Pradesh

District	Length (µm)					Breadth (µm)					Ratio L:B Mean	Causal Organism
	Range					Range						
	Min.	Max.	Mean	SD	CV	Min.	Max.	Mean	SD	CV		
Agra	31.00	40.25	35.032±2.366		6.485	14.23	23.10	16.232±2.701		14.338	2.10	E. cichoracearum
Aligarh	31.68	41.00	36.120±1.692		4.577	14.89	22.98	16.620±2.671		14.114	2.05	E. cichoracearum
Allahabad	32.25	40.68	36.080±2.548		7.105	15.15	23.60	18.180±2.630		14.183	2.08	E. cichoracearum
Bareilly	31.65	41.20	36.115±1.020		2.710	14.61	23.89	18.056±3.377		17.114	2.00	E. cichoracearum
Budaun	31.39	40.65	35.886±1.588		4.202	15.00	22.15	17.215±2.497		13.029	2.05	E. cichoracearum
Bulandshahr	32.81	40.10	36.109±2.403		6.765	14.25	23.66	17.576±2.871		14.995	2.10	E. cichoracearum
Etah	31.87	41.20	36.323±2.077		5.655	16.01	21.00	17.215±2.650		14.223	2.22	E. cichoracearum
Etawah	32.53	40.35	36.086±2.282		6.302	15.65	23.58	17.116±2.576		19.269	2.10	E. cichoracearum
Kanpur	32.76	41.33	36.989±2.218		6.072	14.89	23.25	17.850±2.625		14.222	2.12	E. cichoracearum
Mathura	31.67	40.75	35.895±2.229		6.054	14.66	22.99	16.362±2.630		13.660	2.15	E. cichoracearum
	CD(P<0.05)		0.822					1.118			0.430	

* = Length, breadth and L:B ratio of 100 measurements.
SD = Standard Deviation of mean.
CV = Coefficient of variation.

Table 24

Dimensions* of powdery mildew conidia of *Cineraria* spp. from various districts of Uttar Pradesh

District	Length (µm)					Breadth (µm)					Ratio L:B Mean	Causal Organism
	Range					Range						
	Min.	Max.	Mean	SD	CV	Min.	Max.	Mean	SD	CV		
Agra	29.75	38.75	33.875±4.444		14.157	15.25	22.75	18.326±2.706		15.290	1.81	*S. fuliginea*
Aligarh	29.60	38.98	33.921±4.206		13.596	15.56	21.98	18.220±2.446		13.646	1.75	*S. fuliginea*
Allahabad	30.10	39.25	34.158±4.494		14.002	15.30	22.80	18.805±2.529		13.802	1.78	*S. fuliginea*
Bareilly	31.50	40.16	35.213±4.343		13.609	14.42	23.58	18.363±2.477		14.201	1.86	*S. fuliginea*
Budaun	31.62	40.00	35.108±4.082		13.120	15.63	22.62	18.625±2.676		14.893	1.77	*S. fuliginea*
Bulandshahr	29.28	38.50	33.315±3.805		12.480	14.38	23.70	18.437±2.034		11.438	1.86	*S. fuliginea*
Etah	30.65	39.68	34.682±4.457		14.747	14.10	23.98	18.411±2.411		13.541	1.83	*S. fuliginea*
Etawah	30.25	39.75	34.428±4.788		15.489	15.35	23.15	18.132±2.567		14.217	1.90	*S. fuliginea*
Kanpur	30.72	39.28	34.402±3.662		12.092	15.18	22.67	18.063±2.237		12.066	1.89	*S. fuliginea*
Mathura	29.62	38.50	33.608±4.189		13.290	15.45	22.85	18.214±2.628		14.540	1.84	*S. fuliginea*
	CD(P< 0.05)		1.694					1.000			0.174	

* = Length, breadth and L:B ratio of 100 measurements.
SD = Standard Deviation of mean.
CV = Coefficient of variation.

Table 25

Dimensions* of powdery mildew conidia of C. officinalis from various districts of Uttar Pradesh

District	Length (µm)					Breadth (µm)					Ratio L:B Mean	Causal Organism
	Range					Range						
	Min.	Max.	Mean	SD	CV	Min.	Max.	Mean	SD	CV		
Agra	26.50	31.50	29.000±2.237		7.714	13.65	17.50	15.125±1.724		11.866	1.86	S. fuliginea
Aligarh	27.90	30.67	29.750±2.502		8.652	13.18	17.95	15.095±1.785		12.141	1.90	S. fuliginea
Allahabad	26.66	31.00	28.225±2.198		7.696	13.06	18.65	15.325±1.675		11.418	1.97	S. fuliginea
Bareilly	26.00	32.00	28.665±2.214		7.633	13.86	17.15	14.986±1.776		12.142	1.90	S. fuliginea
Budaun	28.32	31.15	28.821±2.379		8.260	14.00	17.60	15.119±1.894		13.168	1.80	S. fuliginea
Bulandshahr	26.65	30.87	28.118±2.032		6.984	14.55	17.16	15.462±1.815		12.031	1.96	S. fuliginea
Etah	26.75	30.60	27.987±2.647		9.437	13.12	18.79	15.321±1.595		10.547	1.89	S. fuliginea
Etawah	26.00	32.50	29.058±2.383		8.427	13.18	18.96	15.167±1.490		9.957	1.95	S. fuliginea
Kanpur	27.50	32.56	29.765±2.339		8.230	14.19	17.69	15.227±1.723		11.612	1.85	S. fuliginea
Mathura	27.32	31.53	29.162±2.344		8.329	14.10	17.00	14.863±1.767		11.952	1.93	S. fuliginea
	CD($P<0.05$)		0.918					0.684			0.153	

* = Length, breadth and L:B ratio of 100 measurements.
SD = Standard Deviation of mean.
CV = Coefficient of variation.

Table 26

Dimensions* of powdery mildew conidia of Coreopsis spp. from various districts of Uttar Pradesh

District	Length (µm)					Breadth (µm)					Ratio L:B Mean	Causal Organism
	Range					Range						
	Min.	Max.	Mean	SD	CV	Min.	Max.	Mean	SD	CV		
Agra	22.75	33.25	27.765±2.887		10.524	14.00	18.25	13.825±1.789		10.960	2.05	E. cichoracearum
Aligarh	22.56	33.85	28.067±2.875		10.589	15.25	19.60	14.987±2.035		12.649	2.24	E. cichoracearum
Allahabad	24.50	32.60	28.136±2.964		10.747	14.25	18.65	14.350±1.981		12.283	2.30	E. cichoracearum
Bareilly	23.46	33.18	28.060±2.723		9.996	14.67	18.92	13.316±1.986		12.397	2.12	E. cichoracearum
Budaun	24.79	32.58	28.154±2.888		10.601	15.00	19.25	13.817±1.942		12.075	2.16	E. cichoracearum
Bulandshahr	22.25	33.90	27.775±2.911		10.877	15.40	18.28	13.210±1.835		11.243	2.17	E. cichoracearum
Etah	23.80	33.00	27.992±3.060		11.225	14.70	19.56	13.763±1.767		10.907	2.10	E. cichoracearum
Etawah	22.40	33.93	27.865±2.991		11.220	14.62	18.00	13.621±1.997		12.494	2.10	E. cichoracearum
Kanpur	23.31	33.72	28.115±2.845		10.547	15.58	19.17	13.775±2.034		12.723	2.10	E. cichoracearum
Mathura	22.95	33.67	27.910±2.759		10.160	14.65	18.80	13.229±1.969		12.317	2.13	E. cichoracearum
	CD(P< 0.05)		1.137					0.772			0.157	

* = Length, breadth and L:B ratio of 100 measurements.
SD = Standard Deviation of mean.
CV = Coefficient of variation.

Table 27

Dimensions* of powdery mildew conidia of C. sulphureus from various districts of Uttar Pradesh

District	Length (µm)					Breadth (µm)					Ratio L:B Mean	Causal Organism
	Range					Range						
	Min.	Max.	Mean	SD	CV	Min.	Max.	Mean	SD	CV		
Agra	24.50	38.36	30.860±2.147		7.167	15.75	17.50	15.125±1.386		8.982	2.00	E. cichoracearum
Aligarh	25.28	37.65	31.162±4.896		16.076	15.15	17.60	15.228±1.300		8.382	2.15	E. cichoracearum
Allahabad	24.76	38.00	31.080±2.298		7.579	14.90	17.95	15.125±2.646		16.944	2.04	E. cichoracearum
Bareilly	24.35	37.95	30.708±2.740		8.806	15.36	17.82	15.085±1.357		8.895	2.05	E. cichoracearum
Budaun	25.15	37.18	30.660±3.613		12.630	14.86	17.75	14.060±1.436		9.201	2.10	E. cichoracearum
Bulandshahr	25.28	37.42	31.060±5.100		16.133	14.35	17.48	14.315±2.313		14.988	2.14	E. cichoracearum
Etah	24.30	38.25	31.115±2.285		7.529	14.20	17.82	15.610±1.443		9.371	2.03	E. cichoracearum
Etawah	24.21	38.36	31.085±4.815		15.979	15.10	17.75	14.120±1.416		9.151	2.18	E. cichoracearum
Kanpur	24.65	38.50	31.162±2.158		7.168	15.46	17.38	15.050±1.400		9.032	2.10	E. cichoracearum
Mathura	25.10	37.75	30.925±5.189		16.239	14.80	17.71	14.928±4.476		13.050	2.07	E. cichoracearum
	CD(P<0.05)		1.494					0.848			0.168	

* = Length, breadth and L:B ratio of 100 measurements.
SD = Standard Deviation of mean.
CV = Coefficient of variation.

Table 28

Dimensions* of powdery mildew conidia of D. variabilis from various districts of Uttar Pradesh

District	Length (µm)					Breadth (µm)					Ratio L:B Mean	Causal Organism
	Range					Range						
	Min.	Max.	Mean	SD	CV	Min.	Max.	Mean	SD	CV		
Agra	31.50	45.36	37.621±4.476		13.050	17.15	22.65	18.215±2.907		14.451	2.20	E. cichoracearum
Aligarh	31.26	45.48	37.852±4.566		13.684	17.25	24.25	18.300±2.402		12.130	2.05	E. cichoracearum
Allahabad	30.10	44.65	36.720±6.300		13.611	17.68	24.21	17.128±2.968		14.767	2.10	E. cichoracearum
Bareilly	30.56	44.13	36.634±5.159		14.165	17.60	23.15	17.675±2.711		13.483	2.05	E. cichoracearum
Budaun	31.21	45.66	37.782±4.672		14.185	17.35	22.92	18.660±3.091		15.028	2.08	E. cichoracearum
Bulandshahr	31.98	44.52	37.825±4.388		13.127	17.15	23.65	18.980±2.818		14.058	2.02	E. cichoracearum
Etah	31.60	45.25	37.684±4.426		13.266	17.12	24.25	18.185±2.825		14.134	2.15	E. cichoracearum
Etawah	30.75	44.89	37.165±4.780		14.074	17.00	22.75	18.226±3.001		14.969	2.03	E. cichoracearum
Kanpur	31.50	44.10	37.467±7.449		14.534	17.48	23.63	18.159±2.800		14.145	2.05	E. cichoracearum
Mathura	31.40	45.21	37.645±4.891		14.487	17.83	24.00	18.089±2.601		13.148	2.13	E. cichoracearum
	CD(P<0.05)		2.062					1.117			0.180	

* = Length, breadth and L:B ratio of 100 measurements.
SD = Standard Deviation of mean.
CV = Coefficient of variation.

Table 29

Dimensions* of powdery mildew conidia of E. alba from various districts of Uttar Pradesh

District	Length (µm)					Breadth (µm)					Ratio L:B Mean	Causal Organism
	Range					Range						
	Min.	Max.	Mean	SD	CV	Min.	Max.	Mean	SD	CV		
Agra	27.30	35.80	31.223±2.165		7.721	12.25	15.75	13.728±1.539		10.455	2.26	E. cichoracearum
Aligarh	27.60	35.00	30.675±2.172		7.754	12.42	15.80	13.811±1.583		9.912	2.15	E. cichoracearum
Allahabad	26.80	35.96	30.208±2.126		7.478	12.10	15.32	13.727±1.554		9.473	2.10	E. cichoracearum
Bareilly	27.28	35.46	31.130±2.124		7.562	13.00	15.96	14.533±1.573		10.634	2.24	E. cichoracearum
Budaun	26.42	36.10	30.510±2.224		7.906	13.50	16.20	14.122±1.546		9.538	2.05	E. cichoracearum
Bulandshahr	26.38	36.25	30.718±2.338		8.312	12.68	15.90	13.910±1.573		9.556	2.18	E. cichoracearum
Etah	27.10	36.00	31.056±2.250		8.063	13.21	16.18	14.700±1.522		10.374	2.11	E. cichoracearum
Etawah	27.80	35.22	30.132±2.131		7.586	13.62	15.73	13.923±1.523		10.242	2.22	E. cichoracearum
Kanpur	27.50	35.42	31.060±2.226		7.928	12.92	16.25	14.805±1.597		10.581	2.13	E. cichoracearum
Mathura	26.91	36.25	30.105±2.120		7.562	13.30	16.00	14.128±1.941		10.941	2.15	E. cichoracearum
	CD(P≤0.05)		0.877					2.278			0.135	

* = Length, breadth and L:B ratio of 100 measurements.
SD = Standard Deviation of mean.
CV = Coefficient of variation.

Table 30

Dimensions* of powdery mildew conidia of H. annuus from various districts of Uttar Pradesh

District	Length (µm)					Breadth (µm)					Ratio L:B Mean	Causal Organism
	Range					Range						
	Min.	Max.	Mean	SD	CV	Min.	Max.	Mean	SD	CV		
Agra	24.56	31.56	28.040±2.165		7.721	14.00	17.15	15.372±1.076		6.825	1.93	S. fuliginea
Aligarh	23.95	33.62	28.685±2.172		7.754	14.80	16.15	15.162±2.525		6.344	1.89	S. fuliginea
Allahabad	22.60	34.57	28.438±2.126		7.478	15.01	17.82	16.316±1.134		7.137	1.80	S. fuliginea
Bareilly	21.82	32.88	27.216±2.124		7.562	16.80	17.50	17.012±1.160		7.421	1.78	S. fuliginea
Budaun	21.98	30.11	26.012±2.224		7.906	16.10	15.40	15.018±1.142		7.281	1.87	S. fuliginea
Bulandshahr	24.10	33.22	28.462±2.338		8.063	14.62	16.98	15.512±1.107		6.996	1.90	S. fuliginea
Etah	23.91	34.56	29.136±2.250		8.312	14.92	17.33	16.016±1.145		7.309	1.81	S. fuliginea
Etawah	24.26	36.73	30.319±2.131		7.586	15.08	17.64	16.219±1.611		6.349	1.88	S. fuliginea
Kanpur	22.66	37.54	30.016±2.226		7.923	15.92	15.35	16.312±1.219		7.815	1.90	S. fuliginea
Mathura	24.02	32.85	28.525±2.210		7.562	14.32	18.01	16.082±1.142		7.281	1.84	S. fuliginea
	CD(P< 0.05)		0.860					0.548			0.195	

* = Length, breadth and L:B ratio of 100 measurements.
SD = Standard Deviation of mean.
CV = Coefficient of variation.

Table 31

Dimensions* of powdery mildew conidia of X. strumarium from various districts of Uttar Pradesh

District	Length (µm)					Breadth (µm)					Ratio L:B Mean	Causal Organism
	Range					Range						
	Min.	Max.	Mean	SD	CV	Min.	Max.	Mean	SD	CV		
Agra	28.00	43.75	35.365±4.751		14.020	12.25	17.50	14.312±1.915		12.092	2.18	E. cichoracearum
Aligarh	29.62	42.65	36.012±4.811		14.058	13.80	16.35	15.010±1.782		11.032	2.14	E. cichoracearum
Allahabad	30.08	40.83	35.120±4.675		13.800	13.30	15.75	13.962±1.944		12.223	2.16	E. cichoracearum
Bareilly	29.75	40.61	35.090±4.250		12.744	14.75	16.30	15.125±1.876		11.678	2.10	E. cichoracearum
Budaun	29.40	41.00	35.025±5.020		14.618	14.36	17.29	15.228±1.962		12.351	2.20	E. cichoracearum
Bulandshahr	28.78	40.60	34.421±4.642		13.647	14.50	17.13	15.317±1.870		11.701	2.15	E. cichoracearum
Etah	30.25	42.50	36.129±4.829		14.094	12.20	16.79	14.116±1.879		11.664	2.38	E. cichoracearum
Etawah	32.00	40.38	36.018±4.753		13.842	13.15	16.86	14.562±1.951		12.220	2.25	E. cichoracearum
Kanpur	28.15	43.00	35.332±6.239		14.857	12.28	15.31	15.395±1.789		11.110	2.24	E. cichoracearum
Mathura	29.65	41.25	35.024±4.605		13.665	12.39	15.00	15.178±1.885		11.772	2.28	E. cichoracearum
	CD($P < 0.05$)		1.950					0.733			0.213	

* = Length, breadth and L:B ratio of 100 measurements.
SD = Standard Deviation of mean.
CV = Coefficient of variation.

Table 32

Dimensions* of powdery mildew conidia of Z. elegans from various districts of Uttar Pradesh

District	Length (µm)				Breadth (µm)				Ratio L:B Mean	Causal Organism
	Range				Range					
	Min.	Max.	Mean SD	CV	Min.	Max.	Mean SD	CV		
Agra	26.18	42.10	33.712±5.070	15.375	14.00	22.75	16.085±3.424	18.142	2.08	E. cichoracearum
Aligarh	26.28	42.26	33.910±5.208	15.640	14.28	22.92	16.126±3.719	18.948	2.32	E. cichoracearum
Allahabad	26.45	41.98	34.016±5.236	15.807	14.20	22.70	16.624±3.326	16.722	2.18	E. cichoracearum
Bareilly	26.66	41.50	34.002±4.569	13.600	14.56	22.00	16.823±3.364	17.417	2.10	E. cichoracearum
Budaun	26.34	41.58	33.208±4.654	14.196	15.00	21.65	15.935±3.167	16.087	2.05	E. cichoracearum
Bulandshahr	26.81	41.63	33.715±7.362	15.689	15.10	21.82	15.746±3.538	17.954	2.10	E. cichoracearum
Etah	26.25	41.75	33.525±4.676	14.370	14.98	21.24	16.621±3.406	16.972	2.05	E. cichoracearum
Etawah	26.43	42.00	34.028±4.780	14.184	14.55	21.14	16.625±3.291	17.428	2.10	E. cichoracearum
Kanpur	26.81	41.20	33.662±4.992	15.605	15.25	22.65	15.327±3.439	17.677	2.21	E. cichoracearum
Mathura	26.22	42.32	33.247±5.064	15.483	15.20	21.92	15.860±4.010	19.925	2.10	E. cichoracearum
	CD(P<0.05)		2.092				1.374		0.212	

* = Length, breadth and L:B ratio of 100 measurements.
SD = Standard Deviation of mean.
CV = Coefficient of variation.

Table 33

Occurrence of fibrosin bodies in conidia of Compositae samples infected with powdery mildew

District	Conidia With Fibrosin bodies (No. of samples)	Few Conidia without Fibrosin bodies (No. of samples)
Agra (407)	303	104
Aligarh (375)	210	165
Allahabad (260)	128	132
Bareilly (278)	128	150
Budaun (247)	101	146
Bulandshahr (159)	78	81
Etah (307)	149	158
Etawah (209)	97	112
Kanpur (263)	80	183
Mathura (412)	158	254

Figures in parenthesis indicate the number of samples observed.

Table 34

Percent occurrence of fibrosin bodies in conidia and number of fibrosin bodies per conidium of S. fuliginea collected from various districts of Uttar Pradesh

District	Mean Conidia With Fibrosin bodies (%)	Number of Fibrosin bodies per conidium (Mean)
Agra	89.92±3.67	7.39±1.84
Aligarh	86.25±7.16	7.70±1.61
Allahabad	88.68±3.19	8.30±1.18
Bareilly	87.08±3.10	7.78±1.94
Budaun	92.52±2.34	7.38±1.48
Bulandshahr	88.19±8.56	7.64±0.89
Etah	87.49±2.84	9.01±0.77
Etawah	87.15±5.60	8.45±1.26
Kanpur	89.64±4.72	7.74±1.61
Mathura	89.28±2.65	8.11±1.41

Values are based on measurements of 80 conidia per treatment ± Standard deviation.

Table 35

Mean number of fibrosin bodies per conidium in some Compositae plants collected during survey

District	*Cineraria* spp.	*C. officinalis*	*D. sinuata*	*H. annuus*
Agra	6.86 (7-10)	7.23 (6-12)	-	8.10 (5-11)
Aligarh	5.81 (6-10)	8.20 (7-10)	7.15 (7-9)	9.66 (7-11)
Allahabad	7.86 (5-11)	8.89 (7-12)	-	8.15 (6-10)
Bareilly	8.15 (5-11)	7.95 (7-11)	-	7.25 (5-10)
Budaun	7.82 (5-10)	6.21 (6-9)	6.86 (5-10)	8.65 (7-11)
Bulandshahr	7.15 (6-10)	8.69 (7-10)	-	7.08 (6-9)
Etah	9.65 (7-11)	7.55 (5-11)	-	9.83 (7-12)
Etawah	9.89 (7-12)	7.27 (7-11)	-	8.19 (5-12)
Kanpur	7.33 (8-11)	8.32 (5-11)	-	7.58 (6-10)
Mathura	6.85 (5-9)	8.60 (5-11)	-	8.90 (6-12)

Values are mean of 80 observations.
- = Plant not found.

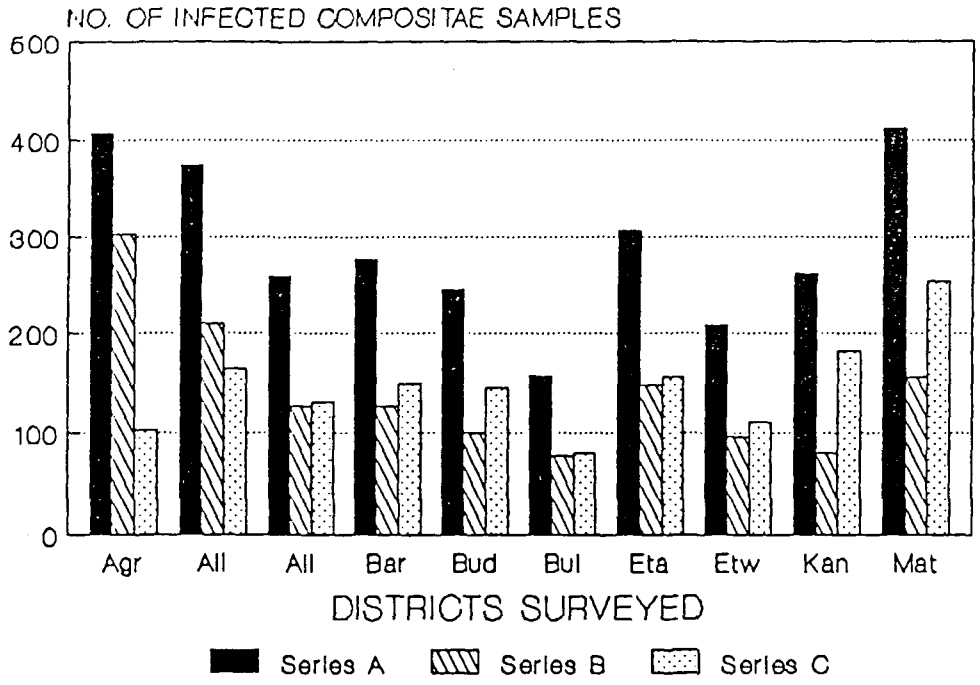
Table 36

Conidial germination and forking/non-forking of germ tubes in powdery mildew samples collected from various districts of Uttar Pradesh

District	Pathogen	Conidial Germination (%)	Forking/Non-Forking of Germ tube (%)	Development of Appressoria
Agra	Sphaerotheca fuliginea	73.67±3.97	56.36±5.58	-
	Erysiphe cichoracearum	80.13±4.80	-	+
Aligarh	S. fuliginea	74.06±5.97	47.96±5.25	-
	E. cichoracearum	69.04±6.83	-	+
Allahabad	S. fuliginea	69.38±9.15	48.83±6.67	-
	E. cichoracearum	72.79±3.46	-	+
Bareilly	S. fuliginea	74.65±7.47	54.77±5.96	-
	E. cichoracearum	77.20±2.57	-	+
Budaun	S. fuliginea	75.08±4.01	54.79±8.63	-
	E. cichoracearum	75.59±3.19	-	+
Bulandshahr	S. fuliginea	79.57±5.23	48.11±9.05	-
	E. cichoracearum	82.07±5.38	-	+
Etah	S. fuliginea	74.93±8.26	52.25±6.53	-
	E. cichoracearum	75.66±3.91	-	+
Etawah	S. fuliginea	76.75±5.12	51.38±8.48	-
	E. cichoracearum	79.21±5.51	-	+
Kanpur	S. fuliginea	76.85±3.14	53.14±8.18	-
	E. cichoracearum	75.43±3.55	-	+
Mathura	S. fuliginea	73.33±6.77	52.46±9.12	-
	E. cichoracearum	83.39±4.95	-	+

Values are based on measurement of 80 conidia per treatment.
± Standard deviation; (-) = No development; (+) = Well developed.

OCCURRENCE OF FIBROSIN BODIES IN CONIDIA OF SPHAEROTHECA FULIGINEA



Agr = Agra	Bul = Bulandshahr
Ali = Aligarh	Eta = Etah
All = Allahabad	Etw = Etawah
Bar = Bareilly	Kan = Kanpur
Bud = Budaun	Mat = Mathura

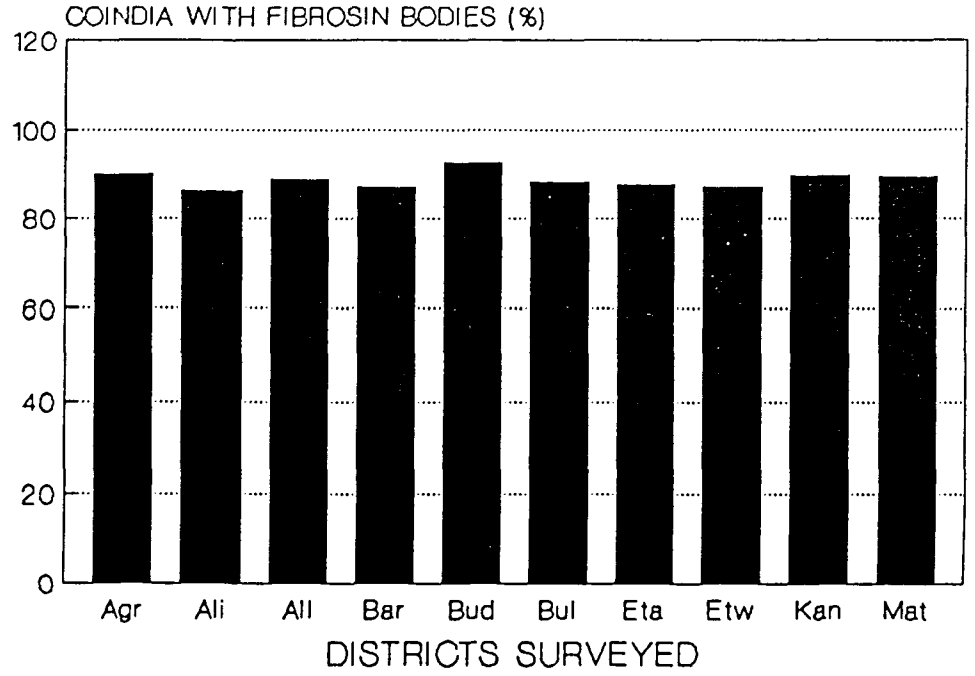
Series A = Total infected Compositae samples studied.

Series B = Number of the samples with all conidia containing fibrosin bodies.

Series C = Number of the samples with few conidia without fibrosin bodies.

FIG. 12

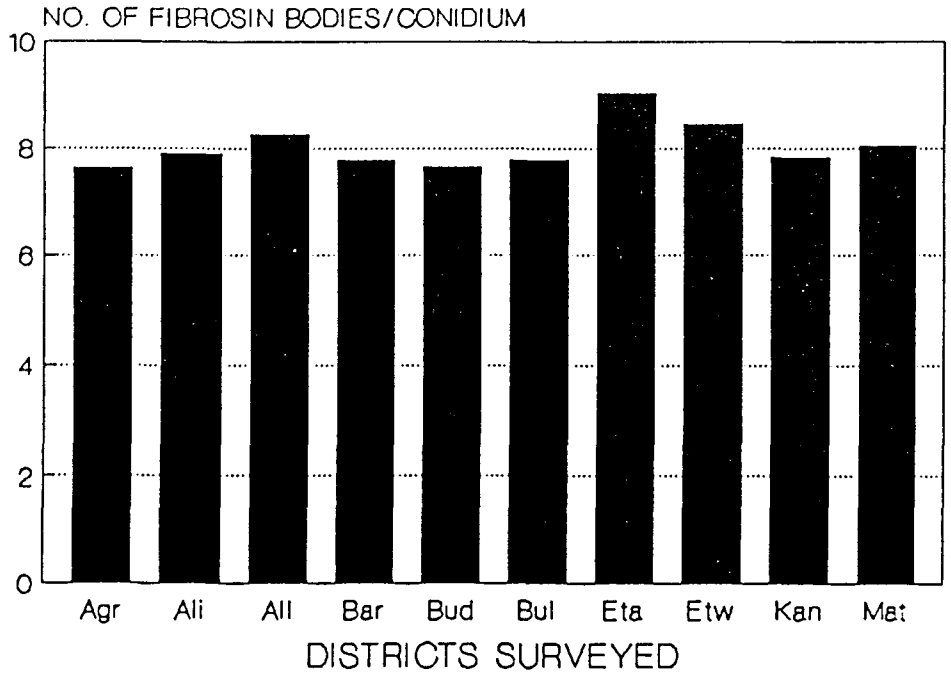
PER CENT OCCURRENCE OF FIBROSIN BODIES IN CONIDIA OF SPHAEROTHECA FULIGINEA



Agr = Agra
Ali = Aligarh
All = Allahabad
Bar = Bareilly
Bud = Budaun
Bul = Bulandshahr
Eta = Etah
Etw = Etawah
Kan = Kanpur
Mat = Mathura

FIG. 13

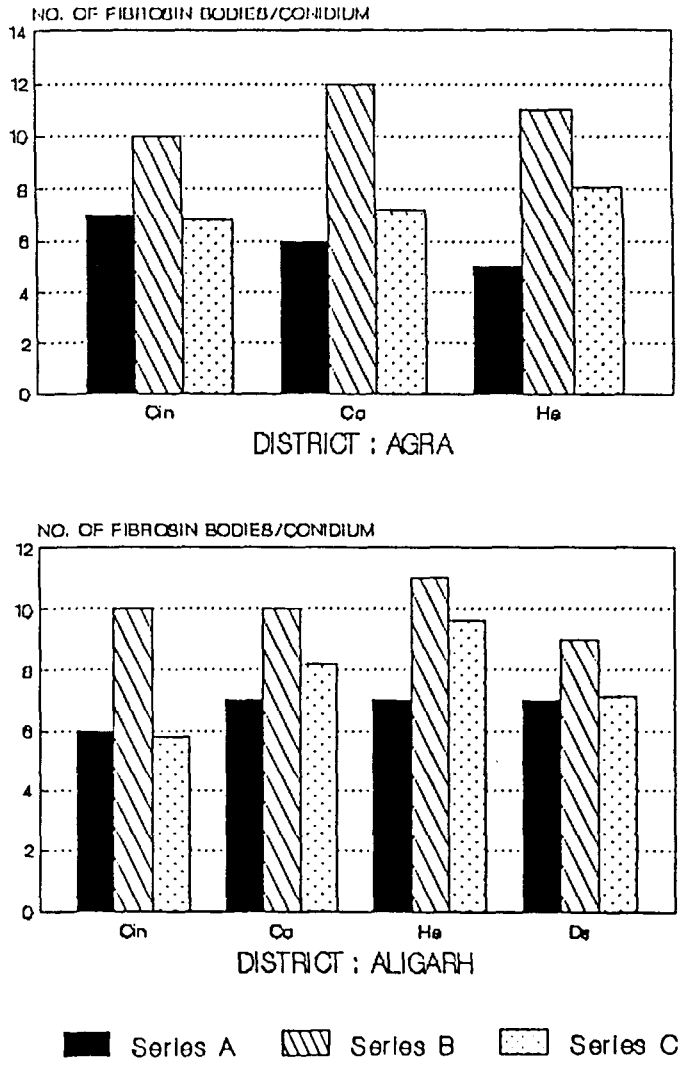
MEAN NO. OF FIBROSIN BODIES/CONIDIUM IN THE CONIDIA OF SPHAEROTHECA FULIGINEA



Agr = Agra	Bul = Bulandshahr
Ali = Aligarh	Eta = Etah
All = Allahabad	Etw = Etawah
Bar = Bareilly	Kan = Kanpur
Bud = Budaun	Mat = Mathura

FIG. 14

NO. OF F.B./CONIDIUM IN COMPOSITAE PLANTS COLLECTED FROM VARIOUS DISTRICTS



Cin = Cineraria spp.

Co = C. officinalis

Ha = H. annuus

Ds = D. sinuata

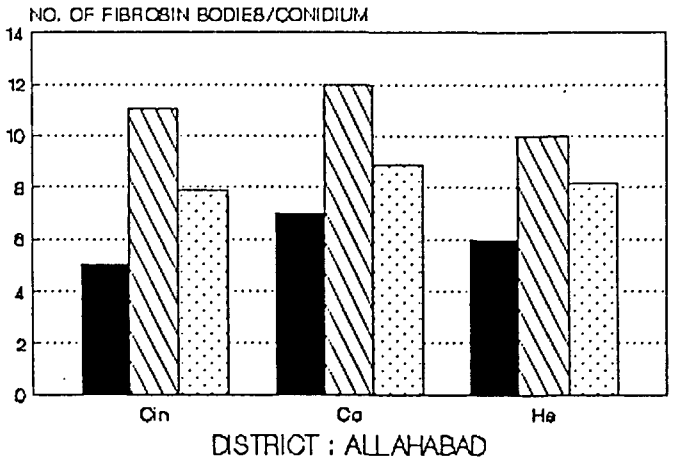
Series A = Minimum number of fibrosin bodies/conidium.

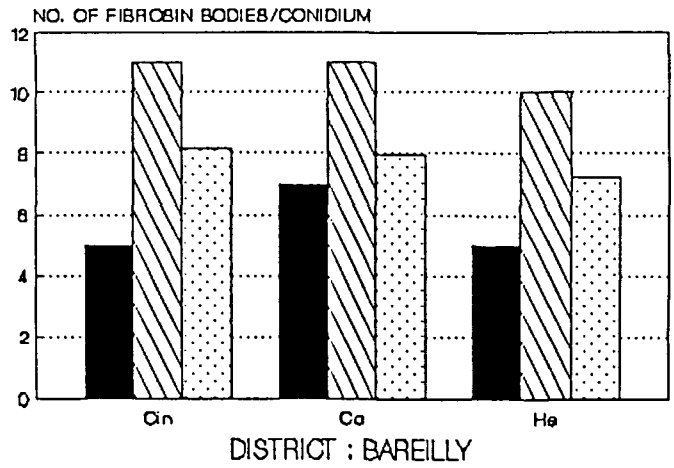
Series B = Maximum number of fibrosin bodies/conidium.

Series C = Mean number of fibrosin bodies/conidium.

FIG. 15

NO. OF F.B./CONIDIUM IN COMPOSITAE PLANTS COLLECTED FROM VARIOUS DISTRICTS





Series A Series B Series C

Cin = Cineraria spp.

Co = C. officinalis

Ha = H. annuus

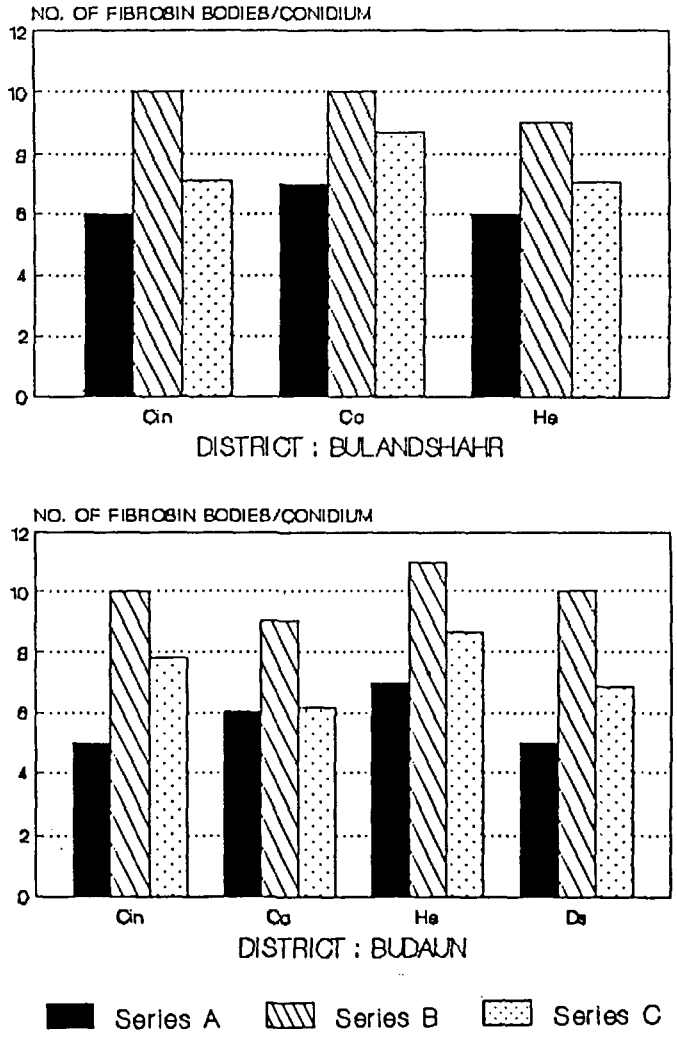
Series A = Minimum number of fibrosin bodies/conidium.

Series B = Maximum number of fibrosin bodies/conidium.

Series C = Mean number of fibrosin bodies/conidium.

FIG. 16

NO. OF F.B./CONIDIUM IN COMPOSITAE PLANTS COLLECTED FROM VARIOUS DISTRICTS



Cin = Cineraria spp.

Co = C. officinalis

Ha = H. annuus

Ds = D. sinuata

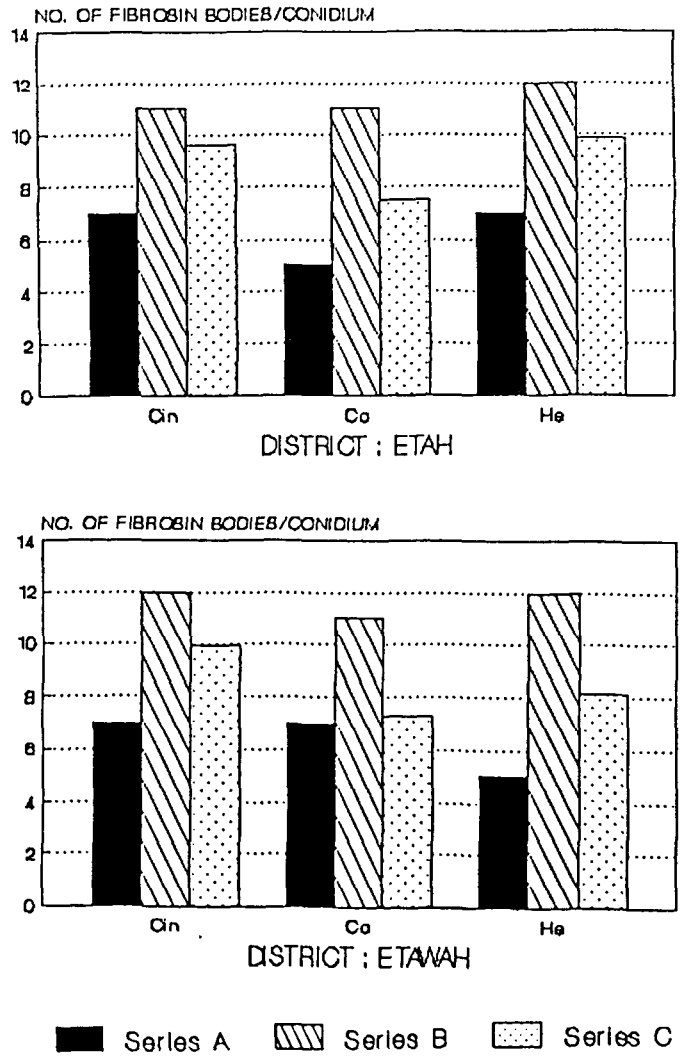
Series A = Minimum number of fibrosin bodies/conidium.

Series B = Maximum number of fibrosin bodies/conidium.

Series C = Mean number of fibrosin bodies/conidium.

FIG. 17

NO. OF F.B./CONIDIUM IN COMPOSITAE PLANTS COLLECTED FROM VARIOUS DISTRICTS



Cin = Cineraria spp.

Co = C. officinalis

Ha = H. annuus

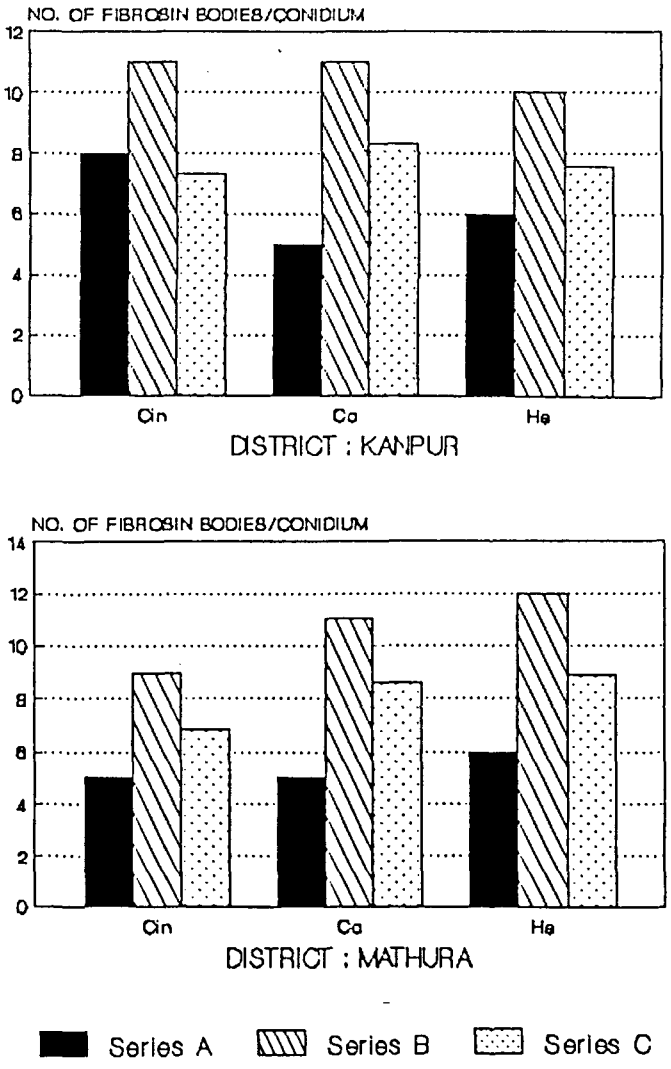
Series A = Minimum number of fibrosin bodies/conidium.

Series B = Maximum number of fibrosin bodies/conidium.

Series C = Mean number of fibrosin bodies/conidium.

FIG. 18

NO. OF F.B./CONIDIUM IN COMPOSITAE PLANTS COLLECTED FROM VARIOUS DISTRICTS



Cin = Cineraria spp.

Co = C. officinalis

Ha = H. annuus

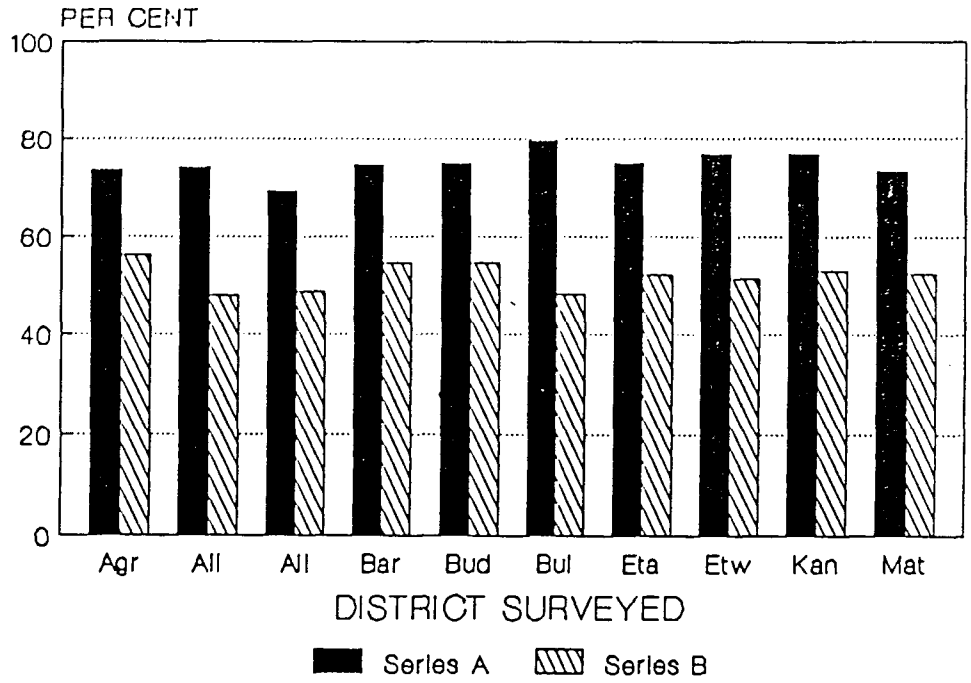
Series A = Minimum number of fibrosin bodies/conidium.

Series B = Maximum number of fibrosin bodies/conidium.

Series C = Mean number of fibrosin bodies/conidium.

FIG. 19

CONIDIAL GERMINATION AND FORKING OF GERM TUBES IN S.FULIGINEA

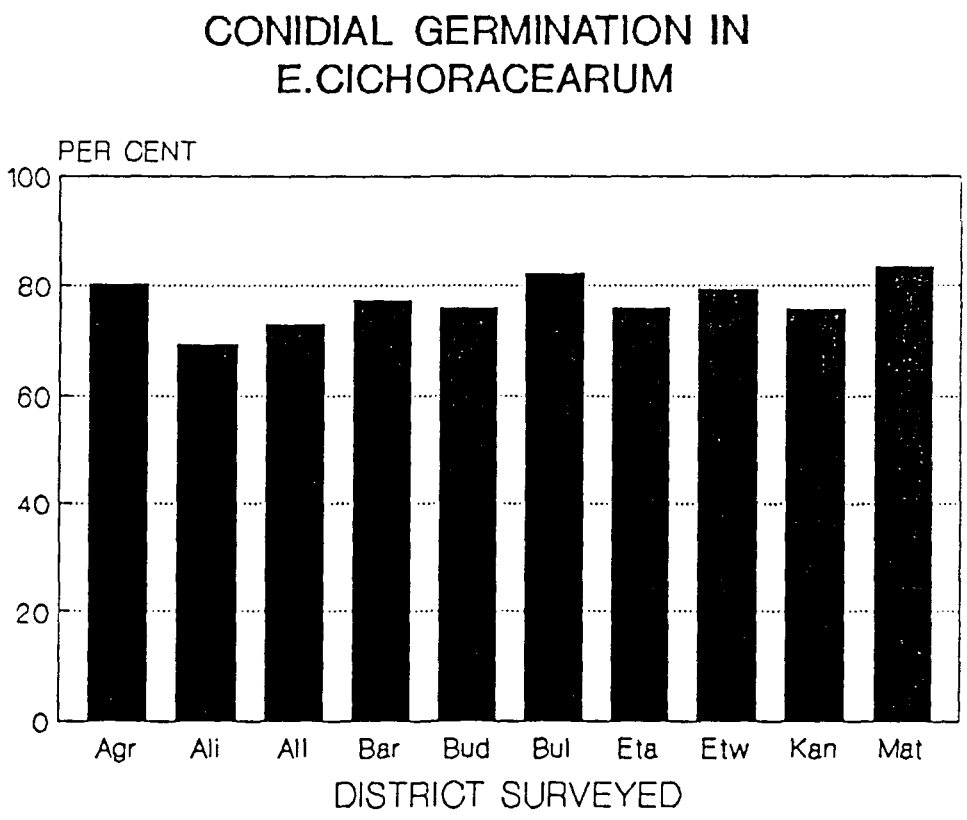


Agr = Agra
Ali = Aligarh
All = Allahabad
Bar = Bareilly
Bud = Budaun
Bul = Bulandshahr
Eta = Etah
Etw = Etawah
Kan = Kanpur
Mat = Mathura

Series A = Total conidial germination of S. fuliginea

Series B = Per cent forking of germinating conidia.

FIG. 20



Agr = Agra
Ali = Aligarh
All = Allahabad
Bar = Bareilly
Bud = Budaun
Bul = Bulandshahr
Eta = Etah
Etw = Etawah
Kan = Kanpur
Mat = Mathura

FIG. 21

from different districts either composite-wise or district-wise and did not show any definite trend. Conidia from the samples of composites on germination produced two types of germ tubes i.e. simple and forked. Forking of germinating conidia was invariably observed in all the samples of composites infected with S. fuliginea. The per cent range of forking was from 47.96 to 56.36. Well developed appressoria was observed at the tip of the germ tube of conidia of E. cichoracearum and these germ tubes emerged from the side/apical portion of the conidia in all the composites infected with powdery mildew. Conidia of S. fuliginea showed a germination range of 69.38 to 79.57 per cent and those of E. cichoracearum 69.04 to 80.13 per cent (Table 36, Fig. 20,21). These characteristics are ample to differentiate the presence of both the pathogens on different members of family Compositae.

Host range studies

For the host range studies twenty cultivated and seven wild plants of the family Compositae were selected. Beside these, eighteen plants of various families were also selected. These plants were tested against Cs (C. sulphureus), Cc (C. coronarium), Dv (D. variabilis) and Ze (Z. elegans) isolates of E. cichoracearum collected from different localities of Aligarh district and maintained in the glasshouse for desired length of time for the inoculation purposes.

It is evident from Table-37 that Cineraria sp., D. variabilis and Z. elegans were susceptible to the Dv isolate under glasshouse and in the field. The Ze isolate produce symptoms on D. variabilis, H. annuus, in addition to its respective host under both the conditions. While Cs and Cc isolates infect only their respective hosts under glasshouse as well as in the field. All the isolates of E. cichoracearum from the above cited hosts failed to infect any of the tested wild composites as well as the plants of different families (Table 38,39).

The isolates of S. fuliginea designated as Ci, Co, Ds and Ha obtained from Cineraria sp., C. officinalis, D. sinuata and H. annuus responded positively only on their respective hosts both under glasshouse and in the field conditions (Tables 40-42).

The isolates of E. cichoracearum from non-composites viz. A. esculentus, B. hispida and C. cordifolia were able to produce symptoms only on their respective hosts and failed to infect cultivated and wild composites as well as the non-composites (Tables 43-45).

Varietal resistance

Single cultivar of C. officinalis viz. Double mixed was resistant and susceptible against Cc (C. coronarium) and Ze (Z. elegans) isolates under glasshouse and in the field (Table 47). It is also clear from the same table that all the four cultivars of C.

coronarium which were tested against isolates of E. cichoracearum from Cs, Cc, Dv and Ze, Coronarium mixed was highly susceptible and susceptible against Cc and Ze isolates, Annual mixed was highly susceptible and resistant against Cc and Ze isolates, while both Maxima may queen and Selection mixed were found to be highly susceptible against Cc isolate in glasshouse as well as in the field.

Table-48 indicates that out of three cultivars of Cineraria sp. tested, only Maxima mixed colours was resistant in field, while susceptible under glasshouse against Dv isolate. Eight cultivars of C. sulphureus were tested against E. cichoracearum and it is clear from the table that all the cultivars showed varying degree of susceptibility against the pathogen under both the conditions. However, Early flowering mixed and Double crested mixed were found to be susceptible under both the conditions against Cs isolate.

Among seven cultivars of D. variabilis tested, Dwarf border mixed and Coltless hybrid mixed were found to be resistant to Ze isolate under glasshouse but highly resistant under field conditions. Dwarf double redskin showed resistance in the field whereas, susceptibility under glasshouse, while Unwins bedding, Decorative mixed and Exhibition mixed were found to be highly susceptible under glasshouse but remain susceptible in the field against Dv isolate (Table 49). Rest of the cultivars showed high resistance to all the isolates of E. cichoracearum tested.

Table 37

Intra family cross-infectivity of isolates of Erysiphe cichoracearum on some cultivated composites

Hosts Inoculated	Sources of isolates							
	Cs		Cc		Dv		Ze	
	F	GH	F	GH	F	GH	F	GH
Acroclinium sp.	R	R	R	R	R	R	R	R
Arctotis sp.	R	R	R	R	R	R	R	R
Aster sp.	R	R	R	R	R	R	R	R
Brachycome iberidifolia	R	R	R	R	R	R	R	R
Calendula officinalis	R	R	R	R	R	R	R	R
Carthamus tinctorius	R	R	R	R	R	R	R	R
Centaurea moschata	R	R	R	R	R	R	R	R
Cosmos sulphureus	S	S	R	R	R	R	R	R
Chrysanthemum coronarium	R	R	S	S	R	R	R	R
Cineraria sp.	R	R	R	R	S	S	R	R
Coreopsis sp.	R	R	R	R	R	R	R	R
Dahlia variabilis	R	R	R	R	S	S	S	S
Dimorphotheca sinuata	R	R	R	R	R	R	R	R
Gaillardia sp.	R	R	R	R	R	R	R	R
Gazania splendens	R	R	R	R	R	R	R	R
Helianthus annuus	R	R	R	R	R	R	S	S
Helichrysum bracteatum	R	R	R	R	R	R	R	R
Lactuca sativa	R	R	R	R	R	R	R	R
Tagetes erecta	R	R	R	R	R	R	R	R
Zinnia elegans	R	R	R	R	S	S	S	S

Cs = Cosmos sulphureus; Cc = Chrysanthemum coronarium;
Dv = Dahlia variabilis; Ze = Zinnia elegans
R = Resistant; S = Susceptible; F = In the Field; GH = Under Glasshouse

Table 38

Intra family cross-infectivity of isolates of *Erysiphe cichoracearum* on some wild composites

Hosts Inoculated	Sources of isolates							
	Cs		Cc		Dv		Ze	
	F	GH	F	GH	F	GH	F	GH
Ageratum conyzoides	R	R	R	R	R	R	R	R
Conyza japonica	R	R	R	R	R	R	R	R
Eclipta alba	R	R	R	R	R	R	R	R
Sonchus oleraceous	R	R	R	R	R	R	R	R
Tridax procumbens	R	R	R	R	R	R	R	R
Vernonia cinerea	R	R	R	R	R	R	R	R
Xanthium strumarium	R	R	R	R	R	R	R	R

Cs = *Cosmos sulphureus*; Cc = *Chrysanthemum coronarium*;
Dv = *Dahlia variabilis*; Ze = *Zinnia elegans*
R = Resistant; F = In the Field; GH = Under Glasshouse

Table 39

Inter family cross-infectivity of isolates of Erysiphe cichoracearum on some non-composites

Hosts Inoculated	Sources of isolates							
	Cs		Cc		Dv		Ze	
	F	GH	F	GH	F	GH	F	GH
Abelmoschus esculentus	R	R	R	R	R	R	R	R
Benincasa hispida	R	R	R	R	R	R	R	R
Cassia occidentalis	R	R	R	R	R	R	R	R
Capsicum annuum	R	R	R	R	R	R	R	R
Chenopodium ambrosioides	R	R	R	R	R	R	R	R
Coriandrum sativum	R	R	R	R	R	R	R	R
Coccinia cordifolia	R	R	R	R	R	R	R	R
Cucurbita maxima	R	R	R	R	R	R	R	R
C. moschata	R	R	R	R	R	R	R	R
Cucumis melo	R	R	R	R	R	R	R	R
C. sativus	R	R	R	R	R	R	R	R
Daucus carota	R	R	R	R	R	R	R	R
Euphorbia hirta	R	R	R	R	R	R	R	R
Foeniculum vulgare	R	R	R	R	R	R	R	R
Impatiens balsamina	R	R	R	R	R	R	R	R
Lagenaria leucantha	R	R	R	R	R	R	R	R
Lycopersicum esculentum	R	R	R	R	R	R	R	R
Nicotiana tabacum	R	R	R	R	R	R	R	R

Cs = Cosmos sulphureus; Cc = Chrysanthemum coronarium;
Dv = Dahlia variabilis; Ze = Zinnia elegans
R = Resistant; F = In the Field; GH = Under Glasshouse

Table 40

Intra family cross-infectivity of isolates of *Sphaerotheca fuliginea* on some cultivated composites

Hosts Inoculated	Sources of isolates							
	Ci		Co		Ds		Ha	
	F	GH	F	GH	F	GH	F	GH
Acroclinium sp.	R	R	R	R	R	R	R	R
Arctotis sp.	R	R	R	R	R	R	R	R
Aster sp.	R	R	R	R	R	R	R	R
Brachycome iberidifolia	R	R	R	R	R	R	R	R
Calendula officinalis	R	R	S	S	R	R	R	R
Carthamus tinctorius	R	R	R	R	R	R	R	R
Centaurea moschata	R	R	R	R	R	R	R	R
Cosmos sulphureus	R	R	R	R	R	R	R	R
Chrysanthemum coronarium	R	R	R	R	R	R	R	R
Cineraria sp.	S	S	R	R	R	R	R	R
Coreopsis sp.	R	R	R	R	R	R	R	R
Dahlia variabilis	R	R	R	R	R	R	R	R
Dimorphotheca sinuata	R	R	R	R	S	S	R	R
Gaillardia sp.	R	R	R	R	R	R	R	R
Gazania splendens	R	R	R	R	R	R	R	R
Helianthus annuus	R	R	R	R	R	R	S	S
Helichrysum bracteatum	R	R	R	R	R	R	R	R
Lactuca sativa	R	R	R	R	R	R	R	R
Tagetes erecta	R	R	R	R	R	R	R	R
Zinnia elegans	R	R	R	R	R	R	R	R

Ci = *Cineraria* sp.; Co = *Calendula officinalis*;
Ds = *Dimorphotheca sinuata*; Ha = *Helianthus annuus*;
R = Resistant; S = Susceptible; F = In the Field; GH = Under Glasshouse

Table 41

Intra family cross-infectivity of isolates of Sphaerotheca fuliginea on some wild composites

Hosts Inoculated	Sources of isolates							
	Ci		Co		Ds		Ha	
	F	GH	F	GH	F	GH	F	GH
Ageratum conyzoides	R	R	R	R	R	R	R	R
Conyza japonica	R	R	R	R	R	R	R	R
Eclipta alba	R	R	R	R	R	R	R	R
Sonchus oleraceous	R	R	R	R	R	R	R	R
Tridax procumbens	R	R	R	R	R	R	R	R
Vernonia cinerea	R	R	R	R	R	R	R	R
Xanthium strumarium	R	R	R	R	R	R	R	R

Ci = Cineraria sp.; Co = Calendula officinalis;
Ds = Dimorphotheca sinuata; Ha = Helianthus annuus;
R = Resistant; F = In the Field; GH = Under Glasshouse

Table 42

Inter family cross-infectivity of isolates of *Sphaerotheca fuliginea* on some non-composites

Hosts Inoculated	Sources of isolates							
	Ci		Co		Ds		Ha	
	F	GH	F	GH	F	GH	F	GH
Abelmoschus esculentus	R	R	R	R	R	R	R	R
Benincasa hispida	R	R	R	R	R	R	R	R
Cassia occidentalis	R	R	R	R	R	R	R	R
Capsicum annuum	R	R	R	R	R	R	R	R
Chenopodium ambrosioides	R	R	R	R	R	R	R	R
Coriandrum sativum	R	R	R	R	R	R	R	R
Coccinia cordifolia	R	R	R	R	R	R	R	R
Cucurbita maxima	R	R	R	R	R	R	R	R
C. moschata	R	R	R	R	R	R	R	R
Cucumis melo	R	R	R	R	R	R	R	R
C. sativus	R	R	R	R	R	R	R	R
Daucus carota	R	R	R	R	R	R	R	R
Euphorbia hirta	R	R	R	R	R	R	R	R
Foeniculum vulgare	R	R	R	R	R	R	R	R
Impatiens balsamina	R	R	R	R	R	R	R	R
Lagenaria leucantha	R	R	R	R	R	R	R	R
Lycopersicum esculentum	R	R	R	R	R	R	R	R
Nicotiana tabacum	R	R	R	R	R	R	R	R

Ci = *Cineraria* sp.; Co = *Calendula officinalis*;
Ds = *Dimorphotheca sinuata*; Ha = *Helianthus annuus*;
R = Resistant; F = In the Field; GH = Under Glasshouse

Table 43

Results of cross-inoculation tests with Erysiphe cichoracearum inoculum from species of Abelmoschus, Benincasa and Coccinia on some cultivated composites

Hosts Inoculated	A. esculentus		B. hispida		C. cordifolia	
	F	GH	F	GH	F	GH
Acroclinium sp.	R	R	R	R	R	R
Arctotis sp.	R	R	R	R	R	R
Aster sp.	R	R	R	R	R	R
Brachycome iberidifolia	R	R	R	R	R	R
Calendula officinalis	R	R	R	R	R	R
Carthamus tinctorius	R	R	R	R	R	R
Centaurea moschata	R	R	R	R	R	R
Cosmos sulphureus	R	R	R	R	R	R
Chrysanthemum coronarium	R	R	R	R	R	R
Cineraria sp.	R	R	R	R	R	R
Coreopsis sp.	R	R	R	R	R	R
Dahlia variabilis	R	R	R	R	R	R
Dimorphotheca sinuata	R	R	R	R	R	R
Gaillardia sp.	R	R	R	R	R	R
Gazania splendens	R	R	R	R	R	R
Helianthus annuus	R	R	R	R	R	R
Helichrysum bracteatum	R	R	R	R	R	R
Lactuca sativa	R	R	R	R	R	R
Tagetes erecta	R	R	R	R	R	R
Zinnia elegans	R	R	R	R	R	R

R = Resistant; F = In the Field; GH = Under Glasshouse

Table 44

Results of cross-inoculation tests with *Erysiphe cichoracearum* inoculum from species of *Abelmoschus*, *Benincasa* and *Coccinia* on some wild composites

Hosts Inoculated	*A. esculentus*		*B. hispida*		*C. cordifolia*	
	F	GH	F	GH	F	GH
Ageratum conyzoides	R	R	R	R	R	R
Conyza japonica	R	R	R	R	R	R
Eclipta alba	R	R	R	R	R	R
Sonchus oleraceous	R	R	R	R	R	R
Tridax procumbens	R	R	R	R	R	R
Vernonia cinerea	R	R	R	R	R	R
Xanthium strumarium	R	R	R	R	R	R

R = Resistant; F = In the Field; GH = Under Glasshouse

Table 45

Results of cross-inoculation tests with Erysiphe cichoracearum inoculum from species of Abelmoschus, Benincasa and Coccinia on some non-composites

Hosts Inoculated	A. esculentus		B. hispida		C. cordifolia	
	F	GH	F	GH	F	GH
Abelmoschus esculentus	S	S	R	R	R	R
Benincasa hispida	R	R	S	S	R	R
Cassia occidentalis	R	R	R	R	R	R
Capsicum annuum	R	R	R	R	R	R
Chenopodium ambrosioides	R	R	R	R	R	R
Coriandrum sativum	R	R	R	R	R	R
Coccinia cordifolia	R	R	R	R	S	S
Cucurbita maxima	R	R	R	R	R	R
C.moschata	R	R	R	R	R	R
Cucumis melo	R	R	R	R	R	R
C.sativus	R	R	R	R	R	R
Daucus carota	R	R	R	R	R	R
Euphorbia hirta	R	R	R	R	R	R
Foeniculum vulgare	R	R	R	R	R	R
Impatiens balsamina	R	R	R	R	R	R
Lagenaria leucantha	R	R	R	R	R	R
Lycopersicum esculentum	R	R	R	R	R	R
Nicotiana tabacum	R	R	R	R	R	R

R = Resistant; S = Susceptible;

F = In the Field; GH = Under Glasshouse

Table 46

Response of different cultivars of Acroclinium spp. , Arctotis spp. and Aster spp. against Erysiphe cichoracearum

Cultivars	Response against isolates							
	Cs		Cc		Dv		Ze	
	F	GH	F	GH	F	GH	F	GH
Acroclinium spp.								
Semi double white pink	0	0	0	0	0	0	0	0
Splendens mixed	0	0	0	0	0	0	0	0
Special mixture	0	0	0	0	0	0	0	0
Arctotis spp.								
Hybrid mixed	0	0	0	0	0	0	0	0
Special hybrid	0	0	0	0	0	0	0	0
Grandis hybrid	0	0	0	0	0	0	0	0
Aster spp.								
Giant mixed	0	0	0	0	0	0	0	0
Double mixed	0	0	0	0	0	0	0	0
Ostrich plume white	0	0	0	0	0	0	0	0
Crego giant mixed	0	0	0	0	0	0	0	0
Teisa stars mixed	0	0	0	0	0	0	0	0
Powder puff mixed	0	0	0	0	0	0	0	0

Cs = Cosmos sulphureus; Cc = Chrysanthemum coronarium;
Dv = Dahlia variabilis; Ze = Zinnia elegans;
F = In the Field; GH = Under Glasshouse; 0 = Highly Resistant

Table 47

Response of different cultivars of C. officinalis; C. tinctorius; and C. coronarium against Erysiphe cichoracearum

Cultivars	Response against isolates							
	Cs		Cc		Dv		Ze	
	F	GH	F	GH	F	GH	F	GH
Calendula officinalis								
Double golden emperor	0	0	0	0	0	0	0	0
Double geisha girl	0	0	0	0	0	0	0	0
Kelmscott giant orange	0	0	0	0	0	0	0	0
Double mixed	0	0	0	1	0	0	1	2
Orange king	0	0	0	0	0	0	0	0
Pacific beauty mixed	0	0	0	0	0	0	0	0
Fiestive gaurd	0	0	0	0	0	0	0	0
Carthamus tinctorius								
Kusumika	0	0	0	0	0	0	0	0
Chrysanthemum coronarium								
Maxima may queen	0	0	3	3	0	0	0	0
Annual mixed	0	0	3	3	0	0	1	1
Selection mixed	0	0	3	3	0	0	0	0
Coronarium mixed	0	0	3	3	0	0	0	2

Cs = Cosmos sulphureus; Cc = Chrysanthemum coronarium;
Dv = Dahlia variabilis; Ze = Zinnia elegans;
F = In the Field; GH = Under Glasshouse; 0 = Highly Resistant
1 = Resistant; 2 = Susceptible; 3 = Highly susceptible.

Table 48

Response of different cultivars of Cineraria spp.; C. sulphureus and Coreopsis spp.against Erysiphe cichoracearum

Cultivars	Response against isolates							
	Cs		Cc		Dv		Ze	
	F	GH	F	GH	F	GH	F	GH
Cineraria spp.								
Maxima mixed colours	0	0	0	0	1	2	0	0
Duplex double flowers	0	0	0	0	0	0	0	0
Early spring glory	0	0	0	0	0	0	0	0
Cosmos sulphureus								
Sensation mixed	2	3	0	0	0	0	0	0
Choice mixed	2	3	0	0	0	0	0	0
Goldcrest	2	3	0	0	0	0	0	0
Sunset	2	3	0	0	0	0	0	0
Bright lights	2	3	0	0	0	0	0	0
Candy stripe	2	3	0	0	0	0	0	0
Early flowering mixed	2	2	0	0	0	0	0	0
Double crested mixed	2	2	0	0	0	0	0	0
Coreopsis spp.								
Flowers all the year round	0	0	0	0	0	0	0	0
Dwarf double sunburst	0	0	0	0	0	0	0	0
Early sunrise	0	0	0	0	0	0	0	0
Sunbeam	0	0	0	0	0	0	0	0
Tall mixed	0	0	0	0	0	0	0	0

Cs = Cosmos sulphureus; Cc = Chrysanthemum coronarium;
Dv = Dahlia variabilis; Ze = Zinnia elegans;
F = In the Field; GH = Under Glasshouse; 0 = Highly Resistant
1 = Resistant; 2 = Susceptible; 3 = Highly susceptible.

Table 49

Response of different cultivars of D. variabilis; and D. sinuata against Erysiphe cichoracearum

Cultivars	Response against isolates							
	Cs		Cc		Dv		Ze	
	F	GH	F	GH	F	GH	F	GH
Dahlia variabilis								
Collasal single mixed	0	0	0	0	0	0	0	0
Dwarf double redskin	0	0	0	0	0	0	1	2
Coltless hybrid mixed	0	0	0	0	0	0	0	1
Dwarf border mixed	0	0	0	0	0	0	0	1
Unwins bedding	0	0	0	0	2	3	0	0
Decorative mixed	0	0	0	0	2	3	0	0
Exhibition mixed	0	0	0	0	2	3	0	0
Dimorphotheca sinuata								
Orange	0	0	0	0	0	0	0	0
Special mixture	0	0	0	0	0	0	0	0
Giant orange	0	0	0	0	0	0	0	0
Glistening white	0	0	0	0	0	0	0	0

Cs = Cosmos sulphureus; Cc = Chrysanthemum coronarium;
Dv = Dahlia variabilis; Ze = Zinnia elegans;
F = In the Field; GH = Under Glasshouse; 0 = Highly Resistant
1 = Resistant; 2 = Susceptible; 3 = Highly susceptible.

Table 50

Response of different cultivars of *Gaillardia* spp. and *G. splendens* against *Erysiphe cichoracearum*

Cultivars	Response against isolates							
	Cs		Cc		Dv		Ze	
	F	GH	F	GH	F	GH	F	GH
***Gaillardia* spp.**								
Mixed	0	0	0	0	0	0	0	0
Grandiflora mixed	0	0	0	0	0	0	0	0
Picta lollypop orange	0	0	0	0	0	0	0	0
Picta lollypop yellow	0	0	0	0	0	0	0	0
Picta lollypop mixed	0	0	0	0	0	0	0	0
Gazania splendens								
Sunshine hybrid mixed	0	0	0	0	0	0	0	0
Hybrid mixed	0	0	0	0	0	0	0	0
Local	0	0	0	0	0	0	0	0

Cs = *Cosmos sulphureus*; Cc = *Chrysanthemum coronarium*;
Dv = *Dahlia variabilis*; Ze = *Zinnia elegans*;
F = In the Field; GH = Under Glasshouse; 0 = Highly Resistant

Table 51

Response of different cultivars of *Helianthus annuus* against *Erysiphe cichoracearum*

Cultivars	Response against isolates							
	Cs		Cc		Dv		Ze	
	F	GH	F	GH	F	GH	F	GH
Helianthus annuus								
Double sungold tall	0	0	0	0	0	0	0	0
Miniature mixed	0	0	0	0	0	0	1	2
Japanese miniature mixed	0	0	0	0	0	0	0	2
Brown fancy mixed	0	0	0	0	0	0	0	1
Giant russian	0	0	0	0	0	0	0	0
Local (a)	0	0	0	0	0	0	0	0
Local (b)	0	0	0	0	0	0	0	0
Single tall yellow	0	0	0	0	0	0	0	0
Mammoth russian	0	0	0	0	0	0	0	0

Cs = *Cosmos sulphureus*; Cc = *Chrysanthemum coronarium*;
Dv = *Dahlia variabilis*; Ze = *Zinnia elegans*;
F = In the Field; GH = Under Glasshouse; 0 = Highly Resistant
1 = Resistant; 2 = Susceptible

Table 52

Response of different cultivars of Lactuca sativa against Erysiphe cichoracearum

Cultivars	Response against isolates							
	Cs		Cc		Dv		Ze	
	F	GH	F	GH	F	GH	F	GH
Lactuca sativa								
Green and paris white	0	0	0	0	0	0	0	0
Wayahead	0	0	0	0	0	0	0	0
Avoidefiance	0	0	0	0	0	0	0	0
Black seeded simpson	0	0	0	0	0	0	0	0
Local	0	0	0	0	1	1	0	0

Cs = Cosmos sulphureus; Cc = Chrysanthemum coronarium;
Dv = Dahlia variabilis; Ze = Zinnia elegans;
F = In the Field; GH = Under Glasshouse; 0 = Highly Resistant
1 = Resistant;

Table 53

Response of different cultivars of Tagetes erecta against Erysiphe cichoracearum

Cultivars	Response against isolates							
	Cs		Cc		Dv		Ze	
	F	GH	F	GH	F	GH	F	GH
Tagetes erecta								
Dwarf double rusty red	0	0	0	0	0	0	0	0
Dwarf double harmony	0	0	0	0	0	0	0	0
Dwarf double mixed	0	0	0	0	0	0	0	0
Spanish brocade	0	0	0	0	0	0	0	0
Lemon King	0	0	0	0	0	0	0	0
Naughty marietta	0	0	0	0	0	0	0	0
Susanna	0	0	0	0	0	0	0	0
Trinity inca orange	0	0	0	0	0	0	0	0
Trinity inca gold	0	0	0	0	0	0	0	0
Tall african mixed	0	0	0	0	0	0	0	0
French dwarf mixed	0	0	0	0	0	0	0	0
Local (a)	0	0	0	0	0	0	0	0
Local (b)	0	0	0	0	0	0	0	0

Cs = Cosmos sulphureus; Cc = Chrysanthemum coronarium;
Dv = Dahlia variabilis; Ze = Zinnia elegans;
F = In the Field; GH = Under Glasshouse; 0 = Highly Resistant

Table 54

Response of different cultivars of Zinnia elegans against Erysiphe cichoracearum

Cultivars	Response against isolates							
	Cs		Cc		Dv		Ze	
	F	GH	F	GH	F	GH	F	GH
Zinnia elegans								
Cerise queen	0	0	0	0	0	0	0	0
Purity	0	0	0	0	0	0	0	0
Violet queen	0	0	0	0	0	1	0	0
Giants of california mixed	0	0	0	0	0	1	0	0
Canary bird	0	0	0	0	0	0	0	0
Crimson monarch	0	0	0	0	0	0	0	0
Rich salman rose	0	0	0	0	0	0	0	0
Ruffled jumbo mixed	0	0	0	0	0	0	0	0
Linearis white	0	0	0	0	0	0	1	1
Golden dawn	0	0	0	0	0	1	2	2
Purple prince	0	0	0	0	0	1	3	3
Dahlia flowered mixed	0	0	0	0	0	1	3	3
California giant mixed	0	0	0	0	0	0	2	2

Cs = Cosmos sulphureus; Cc = Chrysanthemum coronarium;
Dv = Dahlia variabilis; Ze = Zinnia elegans;
F = In the Field; GH = Under Glasshouse; 0 = Highly Resistant
1 = Resistant; 2 = Susceptible; 3 = Highly susceptible

Three cultivars of H. annuus viz. Miniature mixed, Japanese miniature mixed and Brown fancy mixed were found to be resistant and susceptible against Ze isolate under both the conditions (Table-51). Whereas, rest of the cultivars were found to be highly resistant under both the conditions.

It is clear from Table-52 that out of the five cultivars of L. sativa tested, only Local was found to be resistant against Dv isolate in both the conditions. The remaining cultivars showed high resistance to all the isolates tested under glasshouse and in the field conditions. Among thirteen cultivars of Z. elegans tested. Violet queen, Giants of california mixed, Golden dawn, Purple prince and Dahlia flowered mixed showed resistance to Dv isolate under glasshouse but remain highly resistant under field conditions. Cultivar Linearis white shows resistance against Ze isolate under both the conditions, whereas, Golden dawn and California giant mixed were found to be susceptible and Purple prince and Dahlia flowered mixed highly susceptible against Ze isolate under both the conditions. However, all the remaining cultivars failed in the pathogenecity test against isolates of E. cichoracearum (Table-54).

Chemical control

Three commerical fungicides viz. Karathane EC, Bavistin and Morestan was evaluated for their efficacy against powdery mildew (E. cichoracearum) on D. variabilis cv.Decorative mixed. It is

Table 55

Efficacy of fungicides on disease intensity of powdery mildew (*E. cichoracearum*) on *Dahlia variabilis* cv.Decorative mixed

Treatment	Concentration (%)	Percentage disease index		Percentage Disease Control
		Before spray Mean SD	After spray Mean SD	
Karathane EC	0.001	46.21 ± 0.66	8.91 ± 0.56	78.00
	0.01	47.36 ± 0.34	6.10 ± 0.52	84.31
	0.1	45.18 ± 1.10	4.61 ± 0.31	86.85
	0.2	46.52 ± 1.28	2.37 ± 0.24	91.90
	CD($P<0.05$)	1.53	6.42	
Bavistin	0.001	50.03 ± 1.47	10.21 ± 0.47	77.03
	0.01	47.60 ± 2.24	6.78 ± 0.67	82.99
	0.1	46.98 ± 1.00	5.51 ± 0.36	85.43
	0.2	48.35 ± 0.99	4.82 ± 0.10	87.20
	CD($P<0.05$)	4.36	2.31	
Morestan	0.001	47.18 ± 1.81	13.35 ± 0.36	67.21
	0.01	48.09 ± 0.60	11.59 ± 0.39	73.35
	0.1	47.98 ± 1.57	10.21 ± 0.45	76.11
	0.2	48.92 ± 1.28	5.21 ± 0.43	86.56
	CD($P<0.05$)	4.22	2.08	
Control		46.00 ± 1.11	46.00 ± 1.11	

SD = Standard Deviation of Mean.

Mean of three replicates.

clear from Table-55 that higher concentration (0.02 per cent) of these fungicides was most effective in controlling the disease, in comparision to the lower concentrations. Higher concentration of these fungicides were found significantly superior than others. Karathane EC, Bavistin and Morestan have been found to control powdery mildew of D. variabilis cv.Decorative mixed caused by E. cichoracearum. The best performance was observed with Karathane EC (91.90 percentage disease control) followed by Bavistin (87.20 percentage disease control) and Morestan (86.56 percentage disease control). During these studies the phytotoxic symptoms were not observed on the host plants sprayed with these fungicides.

PHOTOGRAPHIC PLATES
(I - X)

Remarks

The figures given in the plates are common to the districts of the study area. They present a general view of symptoms, details of anamorph characters utilized in the study to establish the identity of the species. For this reason the figures are concentrated at one place at the end of the results and are not cited in the text.

PLATE - I

Fig.A: Elongate patches of powdery mildew on the stem of Cosmos sulphureus infected with Erysiphe cichoracearum and severely infected flower.

Fig.B: Flower bud of Dahlia variabilis infected with powdery mildew Erysiphe cichoracearum, showing mild disease intensity.

A

B

PLATE I

PLATE - II

Fig.A: Stem of Cosmos sulphureus with powdery mildew infection, showing yellowing and drying of leaves on the lower portion of the stem.

Fig.B: A close-up of stem portion of Dahlia variabilis infected with powdery mildew and showing patches of mildew with moderate disease intensity.

A

B

PLATE II

A

B

PLATE III

PLATE - IV

Fig.A: Mild infection of powdery mildew Erysiphe cichoracearum on Acroclinium sp.

Fig.B: Leaf of Helianthus annuus infected with powdery mildew Sphaerotheca fuliginea.

A

B

PLATE IV

PLATE - V

Fig.A: Conidial mycelia on the leaves of Coreopsis sp. infected with powdery mildew Erysiphe cichoracearum.

Fig.B: Plant of Eclipta alba infected with powdery mildew Erysiphe cichoracearum, with moderate disease intensity.

A

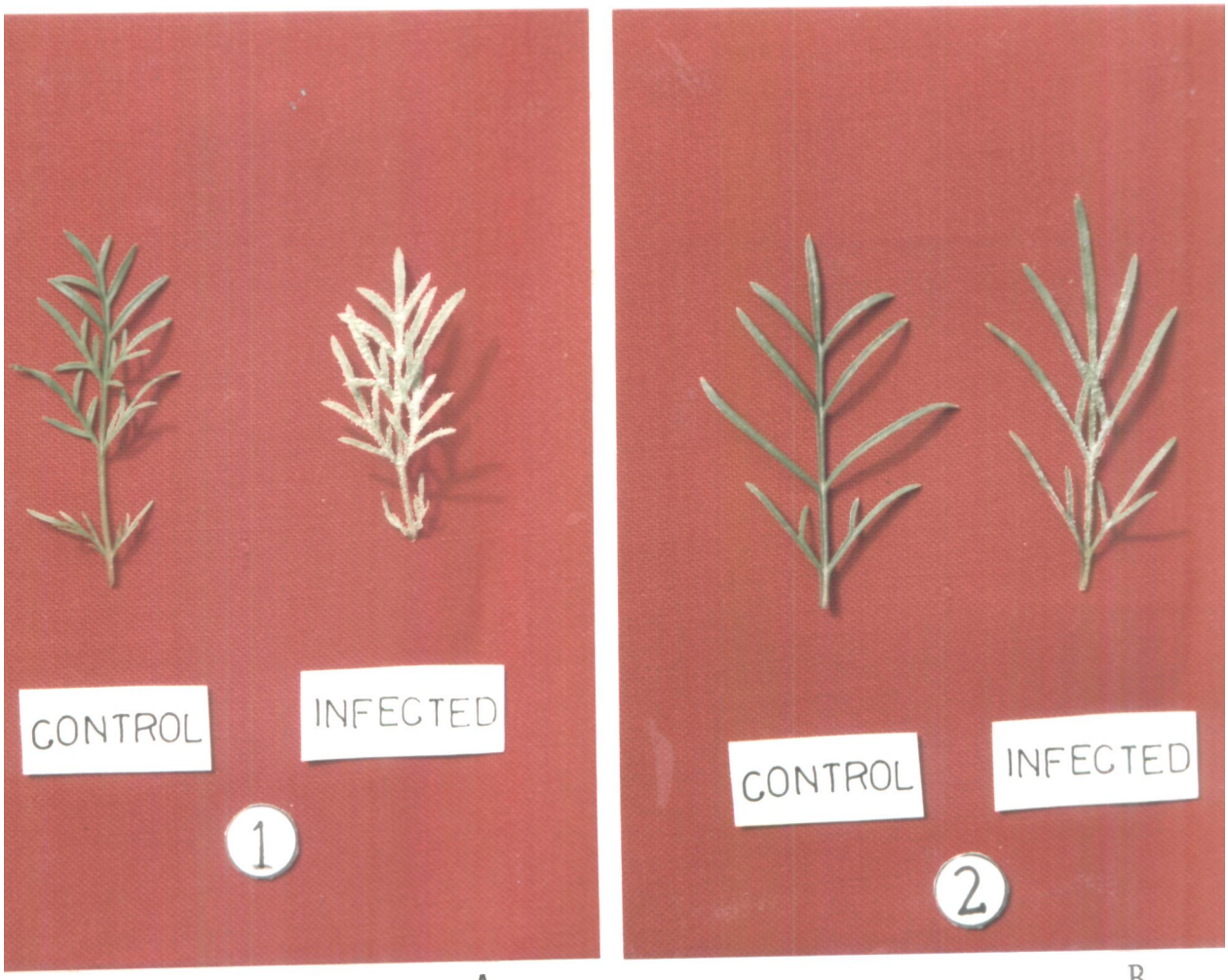
B

PLATE V

PLATE - VI

Fig.A: Uninfected and infected leaf of Cosmos sulphureus cv.Early flowering mixed with powdery mildew Erysiphe cichoracearum.

Fig.B: Uninfected and infected leaf of Cosmos sulphureus cv.Double crested mixed with powdery mildew Erysiphe cichoracearum.



A B

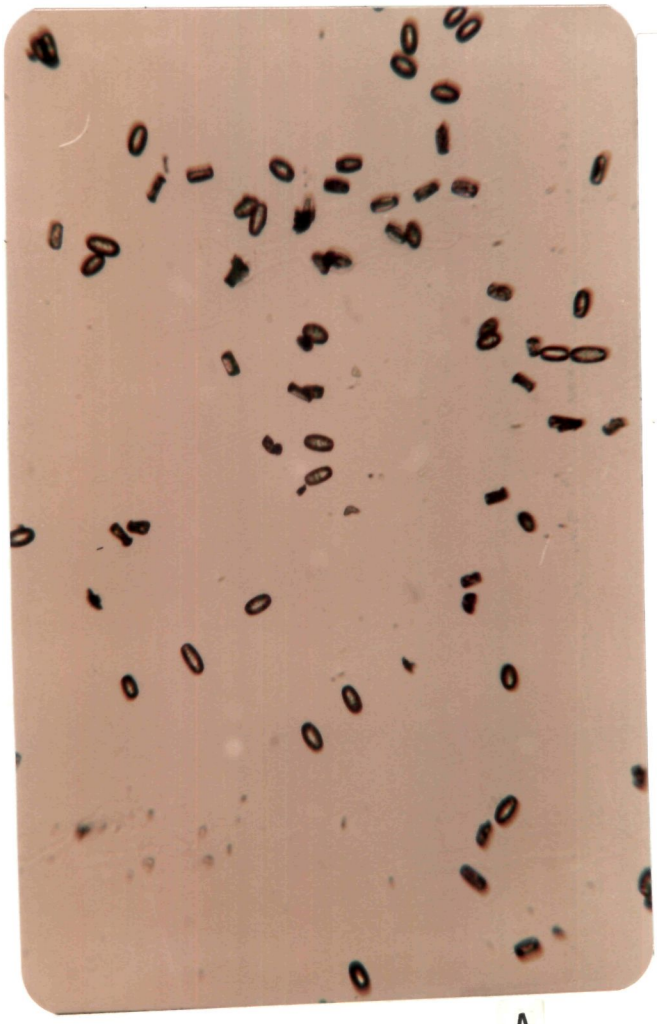
PLATE VI

PLATE - VII

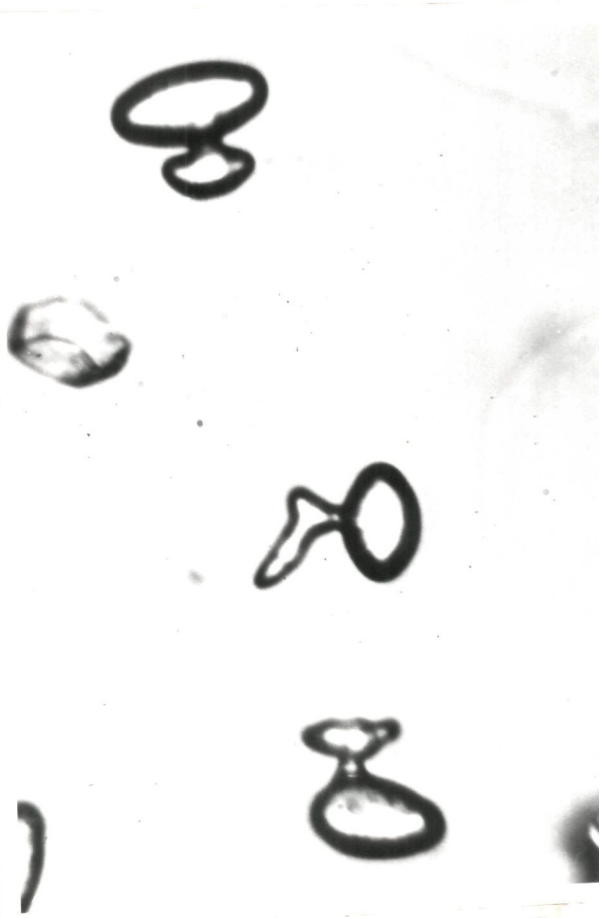
Anamorph characters of Spherotheca fuliginea

Fig.A&B: Ellipsoidal shape conidia of S. fuliginea.

Fig.B : Germinating conidia of S. fuliginea.
Bifurcated germ tube of S. fuliginea emerging from side walls of the conidium.



A



B

PLATE VII

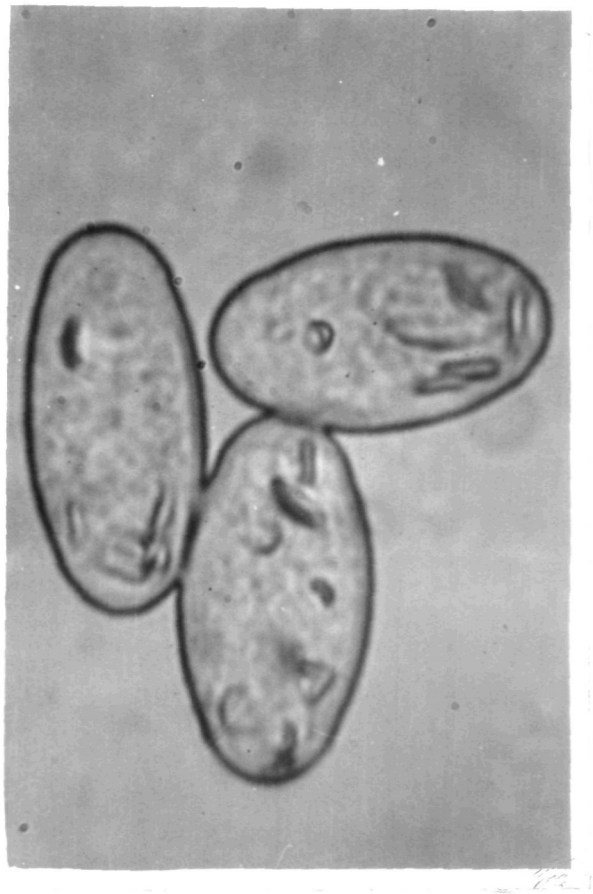
PLATE - VIII

Anamorph characters of *Spherotheca fuliginea*

Fig.A: Conidia with fibrosin bodies seen under low power of the microscope x100.

Fig.B: Well developed, discrete and various shapes of fibrosin bodies seen under high power of the microscope x400.

A



B

PLATE VIII

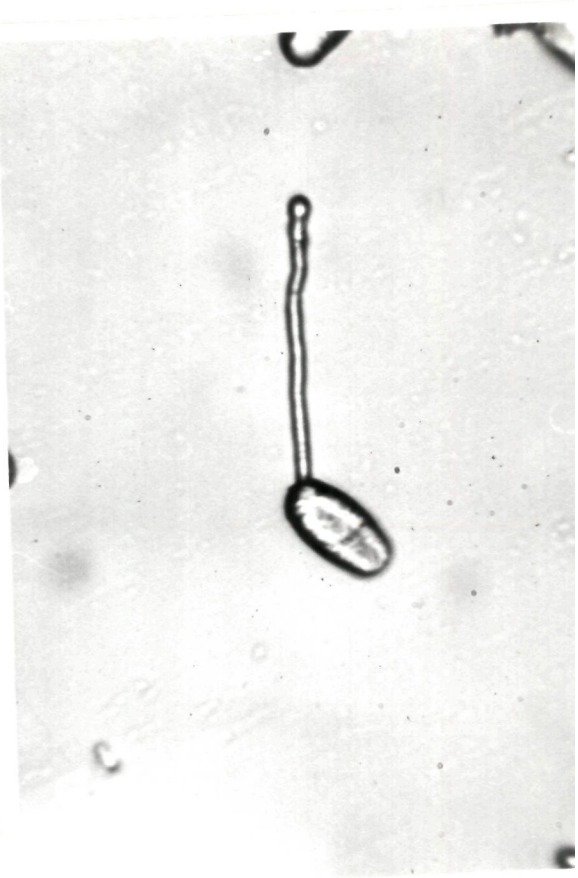
PLATE - IX

Anamorph characters of Erypsiphe cichoracearum.

Fig.A&B: Barrel and tending towards cylindrical shape conidia of E. cichoracearum.

Fig.B : Germinating conidia of E. cichoracearum. Simple and straight germ tube of E. cichoracearum emerging from the apical portion of the conidium.

A



B

PLATE IX

PLATE - X

Anamorph characters of Erypsiphe cichoracearum.

Well developed, club-shaped appressoria at the tip of the germ tube, characteristic of E. cichoracearum.

PLATE X

DISCUSSION

Identity of the causal organism

The major objective of the study was to establish the identity of the causal organisms responsible for the powdery mildew disease on composites in some districts of Uttar Pradesh. The study area included a number of localities in the districts of Agra, Aligarh, Allahabad, Bareilly, Budaun, Bulandshahr, Etah, Etawah, Kanpur and Mathura. Practically it could not be possible to encompass all the districts in the state and at the same time all the areas in the included districts. Still, this study, for the first time in India has given consideration to a large area in order to establish the identity of the causal organisms of the disease on composites. Most of the past studies lacked this objectivity and the available informations on the identity of the species are mostly based on either new host records or reports of occurrence of powdery mildew species. The study has shown that in all the ten districts, Erysiphe cichoracearum and Sphaerotheca fuliginea are predominantly responsible for the disease on composites. Though both the species were found in most of the districts causing the disease on composites, their distribution pattern and host spectrum were quite different.

Various composites like Acroclinium spp., Cineraria spp., C. officinalis, Coreopsis spp., C. sulphureus, D. variabilis, E. alba, H. annuus, X. strumarium and Z. elegans were found infected with powdery mildew from all the surveyed districts (Tables 23-32). Acroclinium spp., Coreopsis spp., C. sulphureus, D. variabilis, E. alba, X. strumarium and Z. elegans were found infected with E. cichoracearum, while Cineraria spp., C. officinalis and H. annuus were found with S. fuliginea from all the surveyed districts. Beside the above mentioned plants, C. coronarium and D. sinuata were also found infected with powdery mildew in few districts. C. coronarium was found infected with E. cichoracearum from the districts of Agra, Aligarh, Etawah, Kanpur and Mathura. Whereas, D. sinuata was found with S. fuliginea from the districts of Aligarh and Budaun. The anamorph state of the fungus was commonly found on these composites. A good amount of repeatability of this pattern of occurrence of the two species of powdery mildews in various districts of this state provide a dependable evidence to recognize them as the causal species of the disease on composites in Uttar Pradesh in general. Though both the species have been recorded as the causal organisms, there are several reports which show their occurrence on the composites, even with its anamorph in various parts of the world including India.

E. cichoracearum and S. fuliginea have been traditionally recorded as the causal organisms with proper verification in many parts of the world, there are several reports which show their occurrence on the composites with only anamorph stage in various parts of the world including India. E. cichoracearum was reported by Milovtzova (1937) on C. tinctorius from U.S.S.R.; McDonald (1939) on Cineraria sp. from Scotland; Backer and Locke (1964) on Zinnia sp. from U.S.A.; Eliade (1975) on Z. elegans from Romania; Mitov and Popov (1980) on H. annuus from Bulgaria; Drozdovskaya (1980) on C. officinalis from U.S.S.R.; Ialongo (1980, 1981) on Sonchus oleraceous and H. tuberosus, Lorenzini and Triolo (1981) on H. annuus from Italy and Diaz Franco (1985) from Mexico; Dhanvantari and Jarwis (1985) and Klemm (1980) on L. sativa from Canada and Germany and Yang (1988) on H. annuus from China, while S. fuliginea by Rud (1939) on C. officinalis from U.S.S.R; Capetti and Gabriela (1976) on Calendula sp. from Romania; Hou and Lee (1981) on Dahlia sp. from Taiwan and Cabrera and Mazzanti (1992) on C. officinalis from Argentina are sufficient to recognize them as causal species of the disease.

In India, on the basis of anamorph characters L. taurica was reported to infect composites in various states. The follow up studies in these districts and reports from other parts of the country do not substantiate its occurrence or significance in the country. In the present studies, the species was not found on any

composite in the studied area. It may be assumed that the species may be appearing occassionally on some composites in localized manner and the significance of the species on composites in Indian context is still obscure. The species though infects some plants in India especially chilli and pepper, but possibility of cross-infection to composites is not great, since a degree of host specialization is reported for the species (Palti, 1988).

A great degree of similarities between the anamorph characters of the two species and usual absence of teleomorphs are additional and important reasons to their mistaken identity. In recent times, Jhooty (1965); Narain and Saksena (1974) in India, utilizing the anamorph characters claimed S. fuliginea and E. cichoracearum as the causal organisms of the disease on composites in Punjab and Kashmir state. Since than a number of reports show that both the species infect composites in various states i.e. in Himachal Pradesh (Paul and Munjal, 1982; Srivastava and Rawat, 1982); Kashmir (Narain and Saksena, 1974); Maharashtra (Saluja and Bhide. 1962; Patwardhan, 1964; Raut and Kale, 1978); Rajasthan (Prasada et al., 1968; Mathur et al. 1971) and in Uttar Pradesh (Akram et al., 1975; Khan et al., 1977; Kanaujia and Singh, 1977; Akram and Khan, 1977; Singh and Singh, 1977; Srivastava and Rawat, 1982; Jain, 1984; Perwez and Akram 1987 and Husain et al., 1992).

The present study has demonstrated convincingly that both E. cichoracearum and S. fuliginea infect composites in the state, though E. cichoracearum is predominant and mainly responsible for the disease on the members of this family and at the same time it confirms the earlier observations made in the country about the identity of the species. Both the species are reported to exist on composites in many countries of the world (Table 5). Some of these are Israel (Eshed, 1975; Kenneth and Palti, 1984); China (Yang, 1988); U.S.S.R. (Drozdovskaya, 1980; Puzanova, 1992); Egypt (El-Kazzaz et al., 1992); Libya (Khan, 1980, 1982; Khan and Faraj, 1982); S. Africa (Gorter and Eicker, 1983); Britain (Crute and Burns, 1983; Bevan, 1985; Clay et al. 1992); Bulgaria (Shopov, 1976; Mitov and Popov, 1980); Czechoslovakia (Lebeda, 1986); France (Hasan, 1974); Germany (Braun, 1980; Klemm, 1986); Italy (Lorenzini and Triolo, 1981; Ialongo, 1981, 1987); Portugal (De' Verennes and De'Sequeira, 1964); Romania (Eliade, 1975; Capetti and Gabriela, 1976); Scotland (McDonald, 1939); Switzerland (Blumer, 1974); Canada (Dhanvantari and Jarwis, 1985); Mexico (Diaz Franco, 1985); U.S.A. (Yarwood, 1936; Pady et al., 1969); Brazil (Deslandes, 1954); Japan (Yukihiko, 1975, 1980); New Zealand (Boesewinkel, 1979a, 1979) and Taiwan (Hou and Lee, 1981).

In the present study the pathogens causing powdery mildew disease in most of the samples were identified only on the basis of anamorph characters. The teleomorph stage of powdery mildews

occurs much less frequently in tropical countries as compared with temperate ones. Owing to the absence of the teleomorph stage in certain powdery mildews, the correct identification becomes difficult. Kable and Ballantyne in 1963, reported that powdery mildew of cucurbits in Ithaca districts was actually S. fuliginea rather than E. cichoracearum as reported earlier. On Z. elegans only E. cichoracearum was reported from India (Butler and Bisby, 1960) and the U.S.A. (U.S.D.A. Index of Plant Diseases, Handbook No. 165, 1960), until Jhooty in 1965 reported S. fuliginea on Z. elegans in India. Up to this time, in India, there is no reliable record of powdery mildews of composites, because of the lack of their teleomorph stages, some powdery mildews on composites were reported to be Oidium species. Zaracovitis (1965), Nagy (1970) and Crute and Burns (1983) attempted to identify different powdery mildews on the basis of the characters of their conidia, the shape of germ tubes, presence or absence of fibrosin bodies and development of appressoria. From personal experience I have found these criteria to be reliable methods for indentification of powdery mildews, in the absence of teleomorph stage.

During the surveys, it was noticed that, the powdery mildew on composites appears in two flushes, one from January to March and other from October to December. It is understandable that during these periods both temperature and relative humidity remains moderate and highly favourable for the development of the disease

as it was also earlier reported by Levykh (1940), Minev (1957), Rossouw (1959), Schnathorst (1960), Morrison (1961, 1964), Malik et al. (1973) and Khan et al. (1975). However, no infection on composites has been observed from April to September, probably, because the temperature remains very high and relative humidity very low in hot season and after that due the rainy season. Similar seasonal fluctuations in disease development had been found by Levykh (1940), Deslandes (1954), Minev (1957), Rossouw (1959) and Schnathorst (1960).

Earlier it was studied by Van Hook (1906), Blumer (1922) and Cook (1931) that increasing age of the host and various environmental factors influence the incidence of powdery mildews. During the course of survey it was observed that different composites showed a variation in the incidence of disease in various localities of the districts.

Schnathorst (1965) has described that distribution and severity of powdery mildews are very much related to various environmental factors and these factors directly affect the pathogen in infection, growth, sporulation and even dissemination. He also pointed out that these factors effect the development of pathogen through their influence on host physiology.

The present study include a number of districts in the state of Uttar Pradesh, where from there was no information about the causal organism of the disease recorded earlier so extensively. Since the study could not include all the districts and states of such a vast country, it is desirable to carry out such studies in the remaining parts of the country, so that emerging information may help the management pathologists to tackle the problem of powdery mildew effectively and efficiently. A distribution map of the species occurrence in various parts of the country showing their relative dominance or host spectrum, therefore, can be prepared which would be conceivably of immense importance for management pathologists, Compositae breeders and growers.

Reliability of anamorph characters

The main reason for the confusion that surrounded the identity of the causal species of the disease on composites was the similarities between the anamorph of E. cichoracearum and S. fuliginea and rare occurrence of teleomorphs. A number of anamorph characters particularly presence or absence of well developed discrete fibrosin bodies, conidial dimensions and L/B ratio, forking of the germ tubes, appressorial development and point of emergence of germ tube from the conidium were considered valuable for differentiating the species. The present study

considered this aspect while examining the large number of samples of cultivated and wild composites. The reliability of anamorph characters were examined in some details. The considered characters such as the conidial dimensions, L/B ratio, presence or absence of fibrosin bodies, forking of germ tubes, appressorial development and point of origin of germ tubes showed a great degree of consistency and are suggested to be reliable to differentiate E. cichoracearum from S. fuliginea.

The use of anamorph characters for establishing the identity of the species was advocated in a number of reviews (Yarwood, 1937; Zaracovitis; 1965; Hammett, 1977; Braun, 1977, 1980; Boesewinkel, 1977, 1979; Nagy, 1970; Crute and Burns, 1983; Khan, 1980, 1982; Khan and Faraj, 1982). In several countries of the world, powdery mildew species involved in the disease on composites were identified on the basis of anamorph characters even though the teleomorphs was not observed. Some of these countries are Britain (Crute and Burns, 1983; Clay et al., 1992), Bulgaria (Shopov, 1976; Mitov and Popov, 1980), Czechoslovakia (Lebeda, 1986), France (Hasan, 1974), Germany (Braun, 1980; Klemm, 1986), Italy (Lorenzini and Triolo, 1981; Ialongo, 1981), Portugal (De'Verennes and De'Sequeira, 1964), Romania (Eliade, 1975) in Europe; Canada (Mckeen et al., 1966), Mexico (Diaz Franco, 1985), U.S.A. (Pady et al., 1969) in North America; Egypt (El-Kazzaz et al., 1992), Libya

(Khan, 1982; Khan and Faraj, 1982) in Africa; Japan (Yukihiko, 1975), New Zealand (Boesewinkel, 1979a, 1979), Taiwan (Hsu and Lee, 1981) in Pacific and China (Yang, 1988), Israel (Eshed, 1975) in Asia continental.

Hirata (1942, 1955), Hammett (1977), Eshed (1975), Ballantyne (1963), Braun (1980) and Boesewinkel (1977, 1979) suggested certain anamorph characters, specially presence of fibrosin bodies and morphology of germ tubes of great taxonomic value for differentiating the powdery mildews. A great degree of consistency observed in the present studies in which a large number of samples were examined, further add to the taxonomic value and importance of these characters specially presence or absence of fibrosin bodies, formation of forked germ tubes, appressorial development and point of germ tube origin. The conidia of powdery mildews identified as S. fuliginea possessed well develop, discrete fibrosin bodies. Though some samples did not show fibrosin bodies in all conidia, a high percentage contained them. The mean number of fibrosin bodies per conidium ranged between 7.38 to 9.01. These were sufficient to give clue towards its identification. However, conidia of S. fuliginea produced simple and forked germ tubes and did not develop appressoria. This pattern of germ tube formation without appressorial development was highly consistent. The per cent forking of germ tubes was between 47.96 to 56.36 (Table 35). Ballantyne (1975) mentioned in her studies that 5 to 60 per cent

conidia of S. fuliginea produce forked germ tubes with more specimens between 3 to 50 per cent. In all the samples identified as S. fuliginea the range of forking was greater and quite common. The conidia of E. cichoracearum formed simple germ tubes with well developed, club-shaped appressoria at the tip of the germ tubes. The conidia of E. cichoracearum were barrel and somewhat cylindrical in shape, whereas, of S. fuliginea were ellipsoidal. The L/B ratio was more or less constant and was found to be an useful criterion. Length/breadth (L/B) ratio of E. cichoracearum was more than 2 (mostly 2.10), while those of S. fuliginea was less than 2 (mostly 1.80) (Tables 23-32) and thus was found to be an important character for the differentiation of both the pathogens.

Ballantyne (1975) in her studies reported that more than one species of powdery mildew may occur in the same locality and on the same plant. In the present studies it was observed that both the pathogens were found in one or the other locality, and different Compositae members were found to be infected with either E. cichoracearum or S. fuliginea. In the majority of the hosts, E. cichoracearum was mainly responsible for the disease on composites. E. cichoracearum with its wide host range and distribution was dominant in the studied districts.

Boesewinkel (1980) in his studies described that the presence of a particular species of powdery mildew on any host is often

influenced by the time of the year. He reported that in New Zealand, E. cichoracearum occurred early in the growing season on H. annuus, but it was replaced by S. fuliginea, several weeks later, on the same plants. No such pathogenic change was observed in the present studies.

By and large measurements of conidia collected from different composites in the same locality or from the same host from different localities indicate that the range of conidial dimensions overlaps in general, however, the mean dimensions (length and breadth) differ significantly in many cases (Tables 23-32). Such differences in the measurements of conidia had also been reported by Neger (1902), Bouwens (1927), Yarwood (1957), Zaracovitis (1965), Nagy (1970), and Crute and Burns (1983). The differences may either be due to the differences in host physiology (Yarwood, 1957) or due to the existance of more than one physiological races of the fungus (Blumer, 1922; Stalkman and Harrar, 1957).

In powdery mildews the size and shape of conidia may differ on different host species (Stavely and Hanson, 1966), on upper and lower surfaces of leaves of the same species (Klika, 1922), or with differences in relative humidity (Yarwood, 1936, 1957). Schmidt (1913) and Bouwens (1927) in their studies reported that the conidial length increases as the relative humidity increases.

During the period of survey it was recorded that the relative humidity among various districts differed significantly throughout the months,when powdery mildew disease was observed (Table 11a&b) and hence, the possibility of variation in conidial size could not be ruled out.

Boesewinkel (1980) advocated that the conidial size shows a more or less marked variation, depending on the species and the growing conditions. Bouwens (1924, 1927) in her studies described that, when a sufficiently large number of conidia were measured, breadth of the conidia was less variable than the length. For several species relatively less variation in conidial length and breadth has been reported, but considerable variation occurs in E. cichoracearum and S. fuliginea (Boesewinkel, 1979).

Boesewinkel (1980) in his studies described that when the conidial characteristics are used, several species which have often been confused can be identified easily. According to Yarwood (1978), confusion in the genera Erysiphe and Sphaerotheca has been mainly confined to E. cichoracearum and S. fuliginea on cucurbits and has been removed by Nagy (1970). These species have apparently identical conidiophores, except for the presence of fibrosin bodies in Sphaerotheca. Until 1960 (U.S.D.A., 1960), powdery mildew on cucurbits was usually listed as E.cichoracearum.

After the recognition of the diagnostic value of fibrosin bodies by Sawada (1927), cucurbit mildew is now usually assigned to S. fuliginea. Similarly, Boesewinkel (1980) suggested that E. cichoracearum and S. fuliginea can be identified by their fibrosin bodies, conidial size, shape and germ tubes. Blumer (1967) and Junnel (1967) also gave much stress on the conidial state characteristics of both the pathogens when the presence or absence of fibrosin bodies, the shape and size of conidia and shape of germ tubes can be studied.

The occurrence of fibrosin bodies in the conidia of S. fuliginea have been emphasized in recent years as a character which distinguishes S. fuliginea (with fibrosin bodies) from E. cichoracearum (without fibrosin bodies) which otherwise have similar conidiophores (Ballantyne, 1963; Clare, 1964; Nagy, 1970). Yarwood (1978) mentioned in his studies that fibrosin bodies-forming cultures do not always have them in every conidium. But his culture of cucumber powdery mildew showed 4 to 8 fibrosin bodies per conidium.

The presence or absence and number of fibrosin bodies in the conidia of S. fuliginea are very much influenced by environmental factors as well as the age of the host. During the present studies it was noted that the number of fibrosin bodies in conidia of

various plants collected differed and the number of fibrosin bodies per conidium showed variation irrespective of the host or the locality and these observations are in accordance with those of Nagy (1970) and Yarwood (1978).

Host range studies

Results on host range studies indicate that the isolates of E. cichoracearum from C. sulphureus, C. coronarium, D. variabilis and Z. elegans infects C. sulphureus, C. coronarium, Cineraria sp., D. variabilis, H. annuus and Z. elegans amongst the cultivated composites (Table 36), while these isolates failed to develop the disease on wild and non-composites (Table 37 and 38). Although this is the first occasion on which the host range of E. cichoracearum and S. fuliginea has been demonstrated, many previous studies have shown that host-restricted forms do indeed occur in E. cichoracearum (Blumer, 1922, 1933; Bouwens 1927; Miller 1938).

The isolates of S. fuliginea from Cineraria sp., C. officinalis, D. sinuata and H. annuus does not parasitize the tested plants except their respective hosts (Tables 39-41). These findings are in accordance with earlier reports of Hirata (1986). Cineraria sp., D. variabilis and H. annuus are some additional hosts of E. cichoracearum under Indian conditions. Similar is the case of

C. officinalis and D. sinuata for S. fuliginea. The isolates of E. cichoracearum from non-composites viz. A. esculentus, B. hispida and C. cordifolia failed in the pathogenecity test against wild as well as cultivated composites tested and all the members of different families except their respective hosts. These results on host range studies confirms the earlier reports of Miller and Barrett (1931), Deslandes (1954), Schmitt (1955), Chandra et al. (1981), Tanaka et al. (1986) and Perwez and Akram (1989).

The isolates of E. cichoracearum from composites appear to be different from those of non-composites. It was observed that isolates of E. cichoracearum from composites viz. C. sulphureus, C. coronarium, D. variabilis, and Z. elegans parasitize C. sulphureus, C. coronarium, Cineraria sp., D. variabilis, H. annuus and Z. elegans but not other composites. Hence, it can be concluded that there may exists different strains of E. cichoracearum showing specificity amongst different plants of Compositae. Similar results were obtained with the isolates of S. fuliginea.

Varietal resistance

Different commercial cultivars of cultivated composites were screened for the varietal resistance. It was observed that reaction against E. cichoracearum isolates obtained from C. sulphureus, C. coronarium, D. variabilis and Z. elegans shows resistance to few

cultivars. It was noticed that the cultivars of C. officinalis (Double mixed); C. coronarium (Maxima may queen, Annual mixed, Selection mixed and Coronarium mixed); Cineraria sp., (Maxima mixed colours), C. sulphureus (Sensation mixed, Choice mixed, Goldcrest, Sunset, Bright lights, Candy stripe, Early flowering mixed, Double crested mixed); D. variabilis (Dwarf double redskin, Coltless hydrid mixed, Dwarf border mixed, Unwins bedding, Decorative mixed, Exhibition mixed); H. annuus (Miniature mixed, Japanese miniature mixed, Brown fancy mixed); L. sativa (Local) and Z. elegans (Violet queen, Giants of California mixed, Linearis white, Golden dawn, Purple prince, Dahlia flowered mixed and California giant mixed) were highly susceptible to resistant against these isolates (Tables 47-49, 51, 52 and 54) whereas, the rest of the cultivars of all the composites tested were found to be highly resistant against E. cichoracearum (Tables 46-54).

Mains (1934), Stanford and Briggs (1940) and Yarwood (1957) in their reviews described that resistance to powdery mildew, or to any other plant pathogen can be due to a specific toxic chemical in resistant but not in susceptible hosts. Most of the plants are resistant to different mildews as well as to many other pathogens, but resistance to one pathogen is not well correlated with resistance to another. It is more likely that resistance is the expression of some chemical released by the host in response to the early stages of penetration by the parasite. Susceptibility is more unusual than

resistance, and if susceptibility, was due to specific susceptibility-inducing chemicals in the host, so these chemicals in each host would need to be investigated, than if resistance was due to specific chemicals (Yarwood, 1957).

In the majority of the tests, the host response in the glasshouse and field was the same. However, in few cases it was observed that the same cultivar remains susceptible under glasshouse but showed resistance in the field or vice versa. Therefore, it is understandable that the glasshouse conditions are a bit controlled and more conducive for the development of powdery mildew rather than the field conditions. It was also reported by various workers that the powdery mildew development in field conditions was influenced by a variety of environmental factors directly or indirectly affecting the pathogen in growth, development, sporulation and dissemination (Delp, 1954; Mansson, 1955; Yarwood, 1957; Cole 1964, 1966 and Schnathorst, 1965).

Chemical control

Diseases caused by powdery mildew pathogen are controlled by exclusion, eradication, protection and therapy, of these, protection with chemicals are perhaps the most important. Because of their superficial position on plants, powdery mildews can be more easily controlled than can most parasitic fungi. Heavy sprays of the host

plant with water (Yarwood, 1957) are moderately effective, but sulphur fungicides are most widely used. Recently, some commercial fungicides like Karathane EC (48 per cent 1-methyl-heptyl) phenylcrotonate, Bavistin (50 per cent 2-methoxy-carbamoyl) benzimidazole) and Morestan (25 per cent 6-methyl-quinoxaline-2,3. dithiocarbonate) and other chemicals (Johnston, 1970) have been shown promising results to control powdery mildew on different plants.

The observed inhibition of powdery mildews by rain naturally suggests its control with water spray. Yarwood (1939), Cherewick (1944), McClellan (1947) and Delp (1954) suggested that spraying of plants with water has been found to render fairly effective in controlling the powdery mildews. In addition, the powdery mildew disease is being controlled by chemical fungicides in the absence of suitable resistant cultivars. So, the comparative efficacy of three commercial fungicides viz. Karathane EC, Bavistin and Morestan was evaluated against the powdery mildew (E. cichoracearum) on Dahlia variabilis cv.Decorative mixed. Though, the percentage disease index was observed to be 47.36, 50.03 and 48.92 per cent before the spray of these fungicides, but, after the spraying of different concentrations of chemical fungicides, significant percentage disease control was recorded. Of the various concentrations of the fungicides applied (0.001, 0.01, 0.1 and 0.2), higher concentration (0.2) of fungicidal spray was found to be most effective in

controlling the disease. It was observed that these fungicides does not allow the subsequent disease development on the host plants. Karathane EC (91.90 percentage disease control) was found to be significantly superior than those of Bavistin (87.20 percentage disease control) and Morestan (86.56 percentage disease control). The present studies are in accordance with those of Pathak and Joshi (1972), Gupta et al. (1975), Srivastava et al (1973) and Nema and Krishna (1982).

Therefore, it is desirable to utilize these three commercial fungicides in controlling powdery mildew of ornamental plants in the absence of suitable resistant cultivars, because these fungicides act in a protective as well as eradicative manner against the powdery mildew pathogen.

SUMMARY

Studies were undertaken to establish the identity of powdery mildew species associated with composites in order to understand their pattern of distribution in a study area comprising ten districts located in western Uttar Pradesh (India). The localities of Agra, Aligarh, Allahabad, Bareilly, Budaun, Bulandshahr, Etah, Etawah, Kanpur and Mathura districts comprised the study area. Powdery mildew infected samples of Acroclinium spp., C. officinalis, C. coronarium, Cineraria spp., Coreopsis spp., C. sulphureus, D. variabilis, D. sinuata, H. annuus, Z. elegans and two wild composites viz. E. alba and X. strumarium were collected from different localities in these districts.

This study for the first time in India constitute such a large area making extensive surveys with the objective to establish the identity of the powdery mildew pathogens and it was established by using anamorph characters of the fungus, in the absence of teleomorph state.

Presence or absence of fibrosin bodies, mode of germination and morphology of germ tubes were used to establish the identity of powdery mildew species responsible for the disease. Erysiphe cichoracearum and Sphaerotheca fuliginea were identified to be present in the study area associated with the composites and found

to be causal organisms for the powdery mildew disease. The species showed variations in their distribution and association with the composites. E. cichoracearum was found infecting Acroclinium spp., Coreopsis spp., C. sulphureus, D. variabilis, E. alba, X. strumarium and Z. elegans in all the districts surveyed, whereas, S. fuliginea was observed infecting Cineraria spp., C. officinalis and H. annuus in all the districts. Beside these, C. coronarium and D. sinuata were also collected with infection in few districts. C. coronarium was found infected with E. cichoracearum from the districts of Agra, Aligarh, Etawah, Kanpur and Mathura. Similarly, S. fuliginea was responsible for infecting D. sinuata in Aligarh and Budaun districts respectively.

Both the species were found as commonest and dominant species in the area occurring frequently. However, L. taurica was not reported in any sample.

A number of anamorph characters particularly presence or absence of well developed discrete fibrosin bodies, conidial dimensions (length and breadth) and L/B ratio, forking of germ tubes and appressorial development and point of emergence of germ tubes from the conidium were examined for their consistency. These anamorph characters were found consistent to a great degree and are suggested reliable for differentiating E. cichoracearum from S. fuliginea.

It can be concluded that the powdery mildew disease is apparently common in the area and most of the commonly grown ornamental composites of the area are liable to suffer damages. E. cichoracearum and S. fuliginea are the species responsible for the disease on composites in the study area. It is expected that this pattern of distribution of the two species of powdery mildews may be found in other districts as well.

Host range studies revealed that Cineraria spp. and Z. elegans were susceptible to D. variabilis isolate of E. cichoracearum; However, D. variabilis and H. annuus were susceptible to Z. elegans isolate of E. cichoracearum both in glasshouse as well as in the field conditions.

The isolates of E. cichoracearum from A. esculentus (Malvaceae) and Benincasa hispida; Coccinia cordifolia (Cucurbitaceae) fail to parasitize the Compositae members. Thus, it can be concluded that the isolates of E. cichoracearum from composites appear to be different from those of non-composites. However, isolates of E. cichoracearum from composites showed different response in the members of Compositae. It can be concluded from these preliminary studies that there exists different strains of E. cichoracearum showing specificity amongst the composites.

Majority of the commercial cultivars of the cultivated composites have been found highly resistant to all the four Compositae isolates, however, few have shown varying degree of susceptibility. The cultivar Double mixed of C. officinalis; Maxima may queen, Annual mixed, Selection mixed and Coronarium mixed of C. coronarium; Maxima mixed colours of Cineraria spp.; Sensation mixed, Choice mixed, Goldcrest, Sunset, Bright lights, Candy stripe, Early flowering mixed and Double crested mixed of C. sulphureus; Dwarf double redskin, Coltless hybrid mixed, Dwarf border mixed, Unwins bedding, Decorative mixed and Exhibition mixed of D. variabilis; Miniature mixed, Japanese miniature mixed and Brown fancy mixed of H. annuus; Local of L. sativa; Violet queen, Giants of California mixed, Linearis white, Golden dawn, Purple prince, Dahlia flowered mixed and California giant mixed of Z. elegans were found to be highly susceptible to resistant in the glasshouse and in the field or vice versa.

Three commercial fungicides viz. Karathane EC, Bavistin and Morestan were evaluated for their efficacy against E. cichoracearum infecting Dahlia variabilis cv.Decorative mixed. Among these fungicides tested, Karathane EC was found to be best in controlling the disease. Higher concentration (0.02 per cent) of these fungicides was also found to be superior in comparison to lower concentrations (0.001,0.01 and 0.1 per cent), in disease control.

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APPENDIX - I

List of Abbreviations

Abst.	Abstract
Fig.	Figure
µm	Micrometer
cm	Centimeter
ft.	Feet
et al.	et alu (= and others)
i.e.	Id est (= that is)
viz.	Videlicet (= namely)
sp.	species
p.	page
pp.	pages

APPENDIX - II

Cultivars of Compositae	Name of the Supplier
Acroclinium sp.	
Semi double white pink	L.R. Bros., Saharanpur
Splendens mixed	Sutton's Seed, Calcutta
Special mixture	Sutton's Seed, Calcutta
Arctotis sp.	
Hybrid mixed	L.R. Bros, Saharanpur
Special hybrid	Sutton's Seed, Calcutta
Grandis hybrid	Sutton's Seed, Calcutta
Aster sp.	
Giant mixed	L.R. Bros., Saharanpur
Double mixed	L.R. Bros., Saharanpur
Ostrich plume white	Sutton's Seed, Calcutta
Crego giant mixed	Sutton's Seed, Calcutta
Teisa stars mixed	Sutton's Seed, Calcutta
Powder puff mixed	Cooper's Seed, Poona
Calendula officinalis	
Double golden emperor	L.R. Bros., Saharanpur
Double geisha girl	L.R. Bros., Saharanpur
Kelmscott giant orange	L.R. Bros., Saharanpur
Double mixed	Poocha Seeds, Poona
Orange king	Poocha Seeds, Poona
Pacific beauty mixed	Poocha Seeds, Poona
Festive gaurd	Sutton's Seed, Calcutta

Carthamus tinctorius	
Kusumika	Sutton's Seed, Calcutta
Chrysanthemum coronarium	
Maxima may queen	L.R. Bros., Saharanpur
Annual mixed	Sutton's Seed, Calcutta
Selection mixed	Sutton's Seed, Calcutta
Coronarium mixed	Cooper's Seed, Poona
Cineraria sp.	
Maxima mixed colours	L.R. Bros., Saharanpur
Duplex double flowers	L.R. Bros., Saharanpur
Early spring glory	Sutton's Seeds, Calcutta
Cosmos sulphureus	
Sensation mixed	L.R. Bros., Saharanpur
Choice mixed	L.R. Bros., Saharanpur
Goldcrest	Sutton's Seed, Calcutta
Sunset	Sutton's Seed, Calcutta
Bright lights	Sutton's Seed, Calcutta
Candy stripe	Sutton's Seed, Calcutta
Early flowering mixed	Cooper's Seed, Poona
Double crested mixed	Cooper's Seed, Poona
Coreopsis sp.	
Flowers all the year round	L.R. Bros., Saharanpur
Dwarf double sunburst	Sutton's Seed, Calcutta
Early sunrise	Sutton's Seed, Calcutta
Sunbeam	Sutton's Seed, Calcutta
Tall mixed	Cooper's Seed, Poona

Dahlia variabilis	
Collasal single mixed	L.R. Bros., Saharanpur
Dwarf double redskin	Sutton's Seed, Calcutta
Coltless hybrid mixed	Sutton's Seed, Calcutta
Dwarf border mixed	Sutton's Seed, Calcutta
Unwins bedding	Cooper's Seed, Poona
Decorative mixed	Cooper's Seed, Poona
Exhibition mixed	Cooper's Seed, Poona
Dimorphotheca sinuata	
Orange	L.R. Bros., Saharanpur
Special mixture	Sutton's Seed, Calcutta
Giant orange	Sutton's Seed, Calcutta
Glistening white	Sutton's Seed, Calcutta
Gaillardia sp.	
Mixed	L.R. Bros., Saharanpur
Grandiflora mixed	Poocha Seeds, Poona
Picta lollypop orange	Sutton's Seed, Calcutta
Picta lollypop yellow	Sutton's Seed, Calcutta
Picta lollypop mixed	Sutton's Seed, Calcutta
Gazania splendens	
Sunshine hybrid mixed	Sutton's Seed, Calcutta
Hybrid mixed	Sutton's Seed, Calcutta
Local	Gaurav Seeds, Aligarh
Helianthus annuus	
Double sungold tall	L.R. Bros., Saharanpur
Miniature mixed	L.R. Bros., Saharanpur
Japanese miniature mixed	Poocha Seeds, Poona
Brown fancy mixed	Poocha Seeds, Poona

Giant russian	Poocha Seeds, Poona
Local (a)	Gaurav Seeds, Aligarh
Local (b)	Punjab Seeds, Aligarh
Single tall yellow	Sutton's Seed, Calcutta
Mammoth russian	Cooper's Seed, Poona
Lactuca sativa	
Green and paris white	L.R. Bros., Saharanpur
Wayahead	Poocha Seeds, Poona
Avondefiance	Sutton's Seed, Calcutta
Black seeded simpson	Sutton's Seed, Calcutta
Local	Gaurav Seeds, Aligarh
Tagetes erecta	
Dwarf double rusty red	Poocha Seeds, Poona
Dwarf double harmony	Poocha Seeds, Poona
Dwarf double mixed	Poocha Seeds, Poona
Spanish brocade	Sutton's Seed, Calcutta
Lemon king	Sutton's Seed, Calcutta
Naughty marietta	Sutton's Seed, Calcutta
Susanna	Sutton's Seed, Calcutta
Trinity inca orange	Sutton's Seed, Calcutta
Trinity inca gold	Sutton's Seed, Calcutta
Tall african mixed	Cooper's Seed, Poona
French dwarf mixed	Cooper's Seed, Poona
Local (a)	Gaurav Seeds, Aligarh
Local (b)	Punjab Seeds, Aligarh.

Zinnia elegans

Cerise queen	Poocha Seeds, Poona
Purity	Poocha Seeds, Poona
Violet queen	Poocha Seeds, Poona
Giants of California mixed	Poocha Seeds, Poona
Canary bird	Poocha Seeds, Poona
Crimson monarch	Poocha Seeds, Poona
Rich salmon rose	Sutton's Seed, Calcutta
Ruffled jumbo mixed	Sutton's Seed, Calcutta
Linearis white	Sutton's Sedd, Calcutta
Golden dawn	Cooper's Seed, Poona
Purple prince	Cooper's Seed, Poona
Dahlia flowered mixed	Cooper's Seed, Poona
California giant mixed	Cooper's Seed, Poona